THE ELECTROMAGNETIC FIELD

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The interpretation of field phenomena presents its own particular difficulties. The processes in space which are responsible for these phenomena are not directly observable and have not yet been formulated in detail. We can only infer these processes from observed effects. Fortunately, for most purposes we can dispense with a detailed interpretation, and deal directly with observed effects at the ordinary scale of magnitude. It is only when we seek to correlate field phenomena with small-scale processes that we need go further.

Field phenomena are concerned with processes in space outside the structure of matter, and with the interaction of these processes with the structure of matter. These phenomena form a sequence: (1) the interaction of the "source" entities in their region; (2) a pattern distributed in space and time; and (3) the interaction of the entity acted upon in its region. Steps (1) and (3) of this sequence may be considered symmetrical; i. e., we assign the same measure number to an entity whether it serves as a source or entity acted upon. These are taken as inverse aspects of the same process.

There is no requirement that quantities assigned for describing field phenomena shall correspond to the physical quantities used for other purposes. We do not have a one to one correspondence between electromagnetic quantities and the usual mechanical quantities, but we do need relationships which make it possible to derive observed results simply and directly. We are dealing with energy differences in space (force) or in time (power); but since observable field effects involve the interaction of a localized entity with a field associated with more distant sources, we do not split a system into the part acted upon and its surroundings in the same manner as is done with other types of phenomena. Instead, we split the usual mechanical quantities into two parts and assign one part to the entity acted upon and the other part to the field background. This is the basic procedure in defining electromagnetic quantities; it makes the product of two such assigned quantities yield a familiar physical quantity such as force or power. We should have no fear of fractional exponents here; they are introduced by definition for our convenience.

Our distribution pattern (step 2) reduces to one in space alone for stationary or quasi-stationary states. In such cases all field phenomena show the simple symmetrical distribution expressed by the inverse square law. For the interaction of two entities we need only assign values to the entities themselves, assuming simply a distribution law and the assignment of quantities characteristic of the interacting entities. Such an approach is familiarly applied to the electrostatic and magnetic fields; it is also applicable to the gravitational field. It expresses the over-all result of the three steps of our sequence, but contains *no* information whatever regarding the small-scale structure of the physical processes involved.

Thus, it is not necessary to resort to special definitions for each type of field structure; one mode of definition serves as a basis for our field units. The units may be derived initially for stationary states, and then applied more generally.

We will consider in some detail the relations which subsist between electromagnetic units and other familiar physical units. With these relations clearly and definitely stated, any needed electromagnetic units may be readily derived. Dimensional relations follow directly from the defining equations; they are in no sense arbitrary, but specific and unambiguous.

It has been well argued that dimensional status should be associated with concepts rather than with units. Unfortunately, electromagnetic concepts have never acquired the uniqueness of definition necessary to make such a course practicable. A concept defined in one specific way thereby acquires a unique, specific dimensional status; there can be no discrepancy or inconsistency in the physical relations which we seek to represent by dimensional methods. It is only when we are faced with more than one definition for any concept that we may have a dimensional status associated with each mode of definition. Such a situation has long existed in electromagnetic theory, and we can hardly hope to remedy it completely. Nevertheless, we can start out by choosing a simple, uniquely defined group of units for use in expressing the fundamental equations. The relationship of this group to other commonly used units is then readily traced. We may include any useful units; such an approach does not essentially restrict our choice. With our dimensional relations clarified, the electromagnetic field is portrayed as a dimensionally self-consistent structure.

The traditional three primary units are units of mass, length, and time. Two of these, length and time, apply to physical concepts which we cannot express or describe in terms of anything more fundamental. The concept of mass is not fundamental in this sense. Mass is generally interpreted as a measure of the intrinsic energy content of matter. Energy appears as the more fundamental physical concept.

Since we cannot readily establish and maintain a unit of energy, we need the traditional primary units to derive and specifiy our unit of energy, as well as the associated units of force (energy/length), and power (energy/time). Field phenomena are directly concerned with energy differences in space (force) and energy changes in time (power). But the preliminary process of deriving units of these quantities from the primary units lies definitely outside the scope of electromagnetic theory. We gain nothing by combining steps which should be kept separate and distinct. We, therefore, omit the preliminary process here, and take units of energy, length and time as initially specified.

We will consider first those units derivable from units of energy and length alone, without the direct introduction of a time unit. Such units obviously are determined initially from resultant forces in stationary states. We will refer to these units as a "basic" group.

We may define a basic erg·cm group, choosing the erg and centimeter as initial units. These units are familiar, being a subgroup of the usual cgs systems, so we will merely summarize them.

Electrostatic forces determine:

Electrostatic charge Q_s: cgse, $(\text{erg·cm})^{1/2}$.
Scalar (electrostatic) potential P: cgse, $(\text{erg/cm})^{1/2} = (\text{dy})^{1/2}$.
Electrostatic field, E and D: cgse, $(\text{dy})^{1/2}/\text{cm}$.

Magnetic forces determine:

Current I: cgsm, $(\text{dy})^{1/2}$.
Vector (magnetic) potential A: cgsm, $(\text{dy})^{1/2}$.
Magnetic field, B and H: cgsm, $(\text{dy})^{1/2}/\text{cm}$.

These units, which have been traditionally assigned to two separate systems, are here used as a single system. As in the Gaussian system we need not distinguish E and D, or B and H, in free space; permittivity and permeability appear

only as dimensionless ratios applicable to regions occupied by matter. They play no part in the specification of our units. Our scalar and vector potentials correspond dimensionally and in magnitude. Electrostatic charge or flux has the dimensional status $(\text{erg} \cdot \text{cm})^{1/2}$, the same as the corresponding unit of magnetic flux, the maxwell.

Expressing these relations requires only two dimensional symbols, since our definitions are based on only two units. Instead of using a symbol for energy directly, it is convenient to set $U = (\text{force})^{1/2}$. This is the dimensional status of our potentials, scalar and vector. Current, the "source" of a vector potential, partakes of the same dimensional status U, while electrostatic charge has the status UL. The field vectors, being the gradient of the scalar potential and the curl of the vector potential, respectively, have the dimensions U/L. We derive at once the relations $U^2L = \text{energy}$, $(U/L)^2 = \text{energy density}$.

These definitions have been specified in terms of stationary state experiments; so, they make no direct use of a time unit. We can apply such a basic group of units more generally, including nonstationary states, without the introduction of additional units; but, with our definitions stated in terms of energy and length alone, we cannot bring in a time unit arbitrarily at this point. Instead, the electromagnetic field itself determines a relation between our space and time coordinates; it gives us a time unit corresponding to our unit of length. The relational factor is of course the familiar velocity, c.

With such a group of units the position of the factor, c, is not arbitrary; it appears wherever time is introduced and nowhere else. Time does not appear independently, but only in conjunction with the factor, c. Experimentally we find that this factor appears not only in obvious propagation processes but in other relations in the electromagnetic field as well, forming an intrinsic part of our field structure. An important such relation, historically the oldest, is the relation between charge and current. In basic units, electrostatic charge = current x time x c.

Unfortunately there exists a general misconception that "quantity of electricity" should have a unique dimensional status, independent of the defining experiments chosen. We do not fall into this error with more familiar matters. No one confuses "bushels of apples" with "pounds of apples," or confuses these measures with an actual counting of the apples. To avoid the somewhat mystical connotation assigned to electromagnetic phenomena, we need to recognize the relation between experimental procedure and dimensional status.

Apart from an actual counting process, which is not generally applicable, there are two principal ways of defining "quantity of electricity." If we state our definition in terms of the forces which quantities of electricity exert on each other, we have an electrostatic unit, with the dimensional status $(\text{force})^{1/2}$ x length. If we first define current, in terms of the forces which currents exert on each other, and then define quantity of electricity as the time integral of a current, this cumulative or electromagnetic unit has the dimensional status $(\text{force})^{1/2}$ x time. The relation between the two units, length/time, a velocity, is inherent in the definitions and can be determined from the defining experiments, without recourse to propagation processes. This fact has, of course, been familiar since Maxwell's day; it served as the basis for his interpretation of the electromagnetic field.

A second relation involving c is the expression for power. We have defined *both* potential and current directly in terms of force; their product appears in units of force (energy/length). To obtain units of power (energy/time), we must multiply by a velocity (length/time). Again the velocity is the familiar factor, c.

It is, thus, actually possible to determine the velocity, c, from the supply of power to a simple resistance, a dramatic illustration of the presence of this velocity as an intrinsic factor in field processes. Of course, in practice it is usually convenient to reverse the procedure, obtaining a direct expression for power by including c implicitly in either the current unit or the potential unit. The tradi-

tional cgs systems may be derived in this way. The position of the factor, c, at this point is vital in coordinating these groups of units.

The velocity, c, probably manifests its most direct significance in the equations of propagation, the familiar "wave equations." Scalar and vector potentials both satisfy such equations, as do their derivatives also. There is good reason to regard the equations of propagation as the fundamental equations of the electromagnetic field. If we make this assumption, the usual field equations are readily derived. We require only one additional condition. To assure conservation of the field energy associated with our potentials, we need a relation between scalar and vector potentials, an "equation of continuity," analogous to the relation between charge and current. These two conditions, propagation and continuity, suffice to determine the electromagnetic field equations (Holm, 1950).

The field equations for a basic group of units are identical with those of the Gaussian system, except that current appears in "electromagnetic" instead of the inconvenient "electrostatic" units; I here corresponds to I/c in the Gaussian system. The same equations are applicable to any basic group. As such a group is specified in terms of only *two* initial units, it is simpler dimensionally than the Gaussian system. It is also more flexible, we can apply the same fundamental equations to a group derived from any desired units of energy and length. Thus, by changing *one* unit in the equations of the Gaussian system, we obtain a group which is more generally useful in describing the structure of the electromagnetic field.

We can apply the same approach to the derivation of the practical electromagnetic units. These units are not derivable directly from the mks units; we will find it convenient to define first a basic erg-meter group, analogous to the above erg-cm group. We retain the same fundamental equations, but c now appears in meters per second instead of cm per second. The unit of force here is the erg per meter, the centidyne or 0.01 dyne. Units of potential, scalar and vector, and current are one-tenth the size of the corresponding cgs basic units. Their dimensional status, $U = (force)^{1/2}$, is here equal to $(erg/meter)^{1/2}$. This current unit is the ampere. The unit of electrostatic charge, UL, $(erg \cdot meter)^{1/2}$, equals 10 cgse.

With the fundamental equations stated for our basic groups, we may readily introduce additional units where convenient and derive equations using them. In particular, for dealing with power and electrodynamic processes, where time is directly involved, we may choose units which make use of the dimensional factor of time, T, in addition to U and L. There is probably only a limited need for cgs units outside the basic group. We shall be more concerned with the quite simple relations between the basic erg-meter group and the practical units which lie outside this group.

Among these units we have the coulomb, the time integral of current in amperes, with the dimensional status UT. The corresponding cgsm equals 10 coul. In either system, the factor c relates such a cumulative unit to the basic electrostatic unit of charge.

In the practical system we express power directly by defining an electrodynamic potential unit: V (volts) $= 10^{-7}$ cP; this is equivalent to volts = watts per ampere. The erg/joule ratio 10^{-7} is not a dimensional factor; it is introduced simply to adjust our order of magnitude. The volt thus has the dimensional status UL/T. The corresponding cgsm, using the product cP, is only 10^{-8} volt.

The ohm (volts per ampere) has the dimensions L/T, a velocity, a status which derives from the presence of the constant, c, in the definition of the volt. Resistance per se does not have this status; in basic units it is a dimensionless ratio. The dimensionless unit of resistance has the same value in any basic group; it is equal to 30 ohms.

The basic potential unit of the erg-meter group is similarly equal to 30 volts. The factor $10^{-7}c$, approximately 30, which appears in these relations, is usually

referred to as a "field impedance" constant. Such a designation unfortunately fails to emphasize its derivation and significance. It is essentially a conversion factor relating units of the basic group, defined in terms of force, to units of the electrodynamic group, associated with power. More specifically, this constant represents the transition from force, in ergs per meter, to power, in joules per second. Its dimensional status remains that of c, and stems from this transition.

Those practical units which are decimally related to corresponding basic units retain the same dimensional status. The weber or volt·second is equal to 10^7 basic ampere·meter units; it has the dimensions UL. A magnetic field expressed in webers per meter^2 has the dimensional status U/L, the same as the curl of the vector potential expressed in amperes per meter, the same factor 10^7 relates these units.

Inductance and capacitance serve most generally as time constants, but they appear within the basic group expressed in units of length; such a group in effect uses a time unit corresponding to the unit of length. The practical unit of inductance, the henry or ohm·second, also has the dimensional status of length; it is equivalent to 10^7 meters. This corresponds to an inductive time constant of 1/30 sec. The farad (coulombs per volt) has the more complicated dimensional status T^2/L. The factor, c, appears twice in its derivation. The farad is equivalent to $c^2/10^7$ or 9×10^9 m, corresponding to a time constant of 30 sec.

If we express inductance and capacitance in time units, impedance will appear in basic dimensionless units. These quantities are all related to the corresponding practical units through the same factor, 30, so the same expression for impedance is applicable.

We see that units of the basic erg·meter group are related to other practical units through simple conversion factors, simpler than the field constants of the currently popular "mks" arrangement. But more importantly, we have gained the advantage of a single set of field equations containing no arbitrary constants.

In addition to the two systems discussed, we can make use of a basic group of units in other ways. We can, for example, readily translate our units to other orders of magnitude. We may choose to reduce our cgs units of energy and length ten decimal places, retaining the dyne for force, and the potential units of the cgs basic group. Such a system gives us simple values for some important constants. We can just as readily specify units suitable for dealing with astronomical magnitudes. We are freed from the restriction to one or two specific groups of units while we retain a single set of fundamental equations throughout their range of validity.

THE ELECTROMAGNETIC FIELD EQUATIONS

The equations are here stated for a basic group of units, which may be derived initially for stationary states, from units of energy and length, or force and length. Time is then introduced as an auxiliary quantity, related to the space coordinates through the velocity, c.

The principal relations in which c appears are:

The relation between charge and current:

$$Q_s = c \int I \, dt, \text{ or } \nabla \cdot \mathbf{i} = -\frac{1}{c} \frac{\partial q}{\partial t}.$$

A similar "equation of continuity" relating scalar and vector potentials:

$$\nabla \cdot \mathbf{A} = -\frac{1}{c} \frac{\partial P}{\partial t}.$$

Equation of propagation, scalar potential:

$$\nabla^2 P - \frac{1}{c^2} \frac{\partial^2 P}{\partial t^2} = -4\pi q.$$

Equation of propagation, vector potential:

$$\nabla^2 \mathbf{A} - \frac{1}{c^2} \frac{\partial^2 \mathbf{A}}{\partial t^2} = -4\pi \mathbf{i}.$$

Power equation:

Power $= cPI$.

We define:

$$\mathbf{B} = \nabla \times \mathbf{A},$$

and:

$$\mathbf{E} = -\nabla P - \frac{1}{c} \frac{\partial \mathbf{A}}{\partial t}.$$

From the equations of propagation and continuity, we derive:

$$\nabla \cdot \mathbf{E} = \nabla \cdot \left(-\nabla P - \frac{1}{c} \frac{\partial \mathbf{A}}{\partial t} \right) = -\nabla^2 P + \frac{1}{c^2} \frac{\partial^2 P}{\partial t^2} = 4\pi q.$$

$$\nabla \times \mathbf{E} = -\frac{1}{c} \frac{\partial}{\partial t} (\nabla \times \mathbf{A}) = -\frac{1}{c} \frac{\partial \mathbf{B}}{\partial t}.$$

$$\nabla \cdot \mathbf{B} = \nabla \cdot (\nabla \times \mathbf{A}) = 0.$$

$$\nabla \times \mathbf{B} = \nabla \times (\nabla \times \mathbf{A}) = \nabla(\nabla \cdot \mathbf{A}) - \nabla^2 \mathbf{A} = -\frac{1}{c} \frac{\partial}{\partial t} (\nabla P) - \nabla^2 \mathbf{A}$$

$$= \frac{1}{c} \frac{\partial \mathbf{E}}{\partial t} + \frac{1}{c^2} \frac{\partial^2 \mathbf{A}}{\partial t^2} - \nabla^2 \mathbf{A} = \frac{1}{c} \frac{\partial \mathbf{E}}{\partial t} + 4\pi \mathbf{i}.$$

LITERATURE CITED

Holm, G. R. 1950. The dimensional structure of the electromagnetic field. Amer. Jour. Phys. 18: 509–514.

THE TOXIC ACTION OF CERTAIN THIO ACIDS ON THE MOLDS OF *PENICILLIUM* AND *ASPERGILLUS* SPP.[1]

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INTRODUCTION

The present paper comprises fungicidal studies carried out on the spores of white mold that developed on different silages when exposed to air. The white mold is composed of a mixture of the *Penicillium* and the *Aspergillus* spp. type. The action of bisulfite solutions on *Pencillium* and *Aspergillus* spp. was reported previously by Pasiut and DeMarinis (1958). The fungicidal studies in the present paper contain the use of (A) tetra- and penta-thionic acid solutions, (B) thiosulfuric acid solutions.

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[1]The fungicidal studies with tetra- and penta-thionic acid mixtures were reported by the authors at the annual meeting of The Ohio Academy of Science, 1958, at Akron, Ohio.

The experiments were carried out on cultures of white molds isolated from old dry silage and are reported in the experimental section.

Young (1922) prepared hydrophilic and hydrophobic sulfur, of which hydrophilic was found to be the most toxic. Young also reported that the toxic property of sulfur is only exhibited when oxygen and water are present. The toxic property of sulfur has been found by Young to be penta-thionic acid. Young and Williams (1928) showed that penta-thionic acid is associated with sulfur. When resublimed flowers of sulfur or ground roll sulfur was triturated with water to effect wetting and then filtered, the clear filtrate had titrable acidity as sulfurous, sulfuric and penta-thionic acids.

Williams and Young (1929) examined the toxicity of sulfuric, dithionic, trithionic, and a mixture of tetra- and penta-thionic acids on the spores of *Sclerotinia cinerea*, and found the mixture of tetra- and penta-thionic acids to be the most toxic.

Oden's colloidal sulfur (1912) with a hydrophilic nature was proven by Freundlich (1926) to contain penta-thionic acid. Weiser and Cunningham (1929) prepared tetra- and penta-thionic acid mixtures by reacting SO_2 and H_2S in aqueous media.

PROCEDURES AND RESULTS

(A) The Action of Tetra- and Penta-Thionic Acid Mixtures

The results of Williams and Young (1929), through the application of a mixture of tetra- and penta-thionic acids to the spores of *Sclerotinia cinerea*, induced the authors to examine the action of these two acids on the spores of *Penicillium* and *Aspergillus* spp. isolated from ailing silages.

Preparation of the mixture.—Into a 500 ml flask, 250 ml distilled water were added and then saturated with sulfur dioxide during continuous stirring. Hydrogen sulfide was introduced at a slower rate than the sulfur dioxide, so that sulfur dioxide was in excess at all times. During two hours of treatment the solution became viscous and the temperature rose from 20° C to 30° C. When this temperature was reached, the sulfur dioxide was shut off and only hydrogen sulfide was kept running until the hydrogen sulfide was in excess and the reaction temperature began to drop. The reaction mixture was corked, allowed to stand over night, and degassified the next day from the excess of hydrogen sulfide by a vacuum aspirator for eight hours.

The degassified reaction mixture was placed in a centrifuge and spun for 5 minutes at 4000 rev/min, which separated the mixture into a paste and liquid phase. The paste was divided into two parts. One part was diluted with water to 250 ml and used in the test as fraction A. The other part was dialyzed. The residue after dialysis was diluted to 250 ml and used as fraction A_1. The dialisate occupied a volume of 400 ml and was used as fraction A_2. The liquid phase which was separated from the paste was also dialyzed and furnished a liquid residue which was diluted to 250 ml and was used as fraction B_1. The liquid dialisate occupied 400 ml and was used as fraction B_2.

Analysis of the different fractions.—Several samples of 5 ml each of A, A_1, A_2, B_1, and B_2 were analyzed for (1) total sulfur as $BaSO_4$, (2) free sulfuric acid as $BaSO_4$, and (3) active sulfur admixed with colloidal sulfur and determined by the difference of (1) and (2).

Total sulfur determination.—The analysis was based on the oxidation of sulfur and of all the sulfur compounds with concentrated nitric acid and liquid bromine. To establish the accuracy of this method, several samples of sulfur were treated with 3 ml of liquid bromine in 15 ml of concentrated nitric acid, resulting in evolution of heat in the reaction mixture. The reaction vessel was then placed on a water bath and carefully controlled to avoid bumping by vaporization of the excess bromine. When the solution was cleared of bromine, the excess nitric and

hydrobromic acids were evaporated by placing the residue in a large crucible and evaporating the excess water and volatile acids until fuming ceased. The residue represented a dilute sulfuric acid, which was precipitated down with barium chloride as in any standard sulfate determination. The accuracy of the method was determined by using sublimed sulfur; and the values obtained were within 0.5 percent. This method was used to determine the total sulfur as barium sulfate in samples of A, A_1, A_2, B_1, and B_2.

Free sulfuric acid determination.—For determination of the free sulfuric acid, the thionic acids were removed, according to the method of Mellor (1935), by precipitating them out with mercurous nitrate. Mercurous nitrate formed voluminous yellow precipitate with tetra- and penta-thionic acids. The absence of tri-thionic acid was indicated by the lack of black precipitate. The precipitation was carried out until no more yellow precipitate was formed by the addition of mercurous nitrate. Then, it was washed with distilled water on the filters until the wash fluids did not give the sulfate reaction.

The wash fluids and filtrate were united, evaporated to a smaller volume, and then precipitated with barium chloride as in any standard sulfate determination. The barium sulfate precipitate was heated strongly in the crucible on account of the possible coprecipitation with excess of mercurous nitrate, which evaporates by decomposition.

Colloidal and active sulfur determination.—By subtracting the weight of free sulfuric acid as barium sulfate from the weight of the total sulfur as barium sulfate, the weight of colloidal and active sulfur as barium sulfate was obtained. As seen in table 1, column 1 indicates the total volume of the fraction; column 2, the volume analyzed; column 3, total sulfur content expressed as $BaSO_4$; column 4, the free sulfuric acid as $BaSO_4$; and column 5, the colloid and active sulfur which contains the poly-thionic acids obtained by the difference between columns 3 and 4.

Toxicity tests.—The molds for the toxicity tests were isolated from ailing silage by standard methods and grown on Sabouraud's agar media. The mold colonies appeared between the 24 and 48 hour period. The number of colonies is taken as a measure of the effectiveness of the additive agents. The test results in table 2 indicate: (1) that the most active fractions were A and A_1 which should contain the most toxic tetra- and penta-thionic acid mixture. This assumption was based on Williams and Young's finding (1929) which stated that di-thionic acid was slightly more toxic than sulfuric acid and tri-thionic less toxic than the mixture of tetra- and penta-thionic acids; (2) that the toxicity of the fractions reduces with a decrease in concentration; (3) that the active components of A did not readily pass through the membranes by dialysis as shown in fraction A_1; (4) that the dialisate in A_2 is not active; and (5) that the high sulfuric acid content which is observed in fractions B_1 and B_2 did not contribute much to the toxicity, but possibly acted as a peptizing agent for the formation of colloidal sulfur.

(B) *The Actions of Thiosulfate Solutions*

Roach and Glyne (1928) attributed the toxic effect caused by an acidified solution of sodium thiosulfate to the free thiosulfuric acid. This theory was opposed by Williams and Young (1929) because of the short life of the free acid. It decomposes within a few minutes according to the equation:

$$H_2S_2O_3 \rightarrow H_2 S O_3 + S$$
$$\swarrow \quad \uparrow$$
$$H_2O + SO_2$$
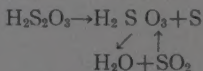
from which again penta-thionic acid is formed according to Riesenfeld and co-workers (1928) by the freshly formed colloidal sulfur.
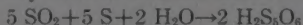
$$5 SO_2 + 5 S + 2 H_2O \rightarrow 2 H_2S_5O_6$$

TABLE 1

Analytical data on fractions A, A_1, A_2, B_1, and B_2

Total volume of fraction	Volume analyzed (in ml)	Total S as BaSO$_4$	Free H$_2$SO$_4$ as BaSO$_4$	Colloid S and active S as BaSO$_4$	pH of the fraction
Fraction A	5	.4470	.0102	.4368	pH 1.5
250 ml	1	.0894	.0020	.0874	
	0.5	.0447	.0010	.0437	
	0.25	.0224	.0005	.0219	
	0.1	.0089	.0002	.0087	
Fraction A$_1$	5	.4344	.0043	.4301	pH 3
250 ml	1	.0869	.0009	.0860	
	0.5	.0435	.0005	.0430	
	0.25	.0218	.0003	.0215	
	0.1	.0087	.0001	.0086	
Fraction A$_2$	5	.0130	.0058	.0072	pH 3
400 ml	1	.0026	.0012	.0014	
	0.5	.0013	.0006	.C007	
	0.25	.0007	.0003	.0004	
	0.1	.0003	.0002	.0001	
Fraction B$_1$	5	1.1749	.3621	.8128	pH 1
250 ml	1	.2350	.0724	.1626	
	0.5	.1175	.0362	.0813	
	0.25	.0588	.0181	.0407	
	0.1	.0235	.0072	.0163	
Fraction B$_2$	5	.4129	.1318	.2811	pH 1
400 ml	1	.0826	.0263	.0562	
	0.5	.0413	.0132	.0281	
	0.25	.0206	.0066	.0140	
	0.1	.0083	.0026	.0057	

TABLE 2

Toxicity tests of the different fractions containing tetra- and penta-thionic acids on mold growth

	Volume of fraction added* (in ml)	pH of fraction	No. of colonies 6/13 11 AM	6/14 9 AM	6/17 12 PM	6/28 12 PM	pH of media after addition of fraction
Fraction A paste separated by	1	1.5	0	0	0	0	5
centrifuge from liquid	0.5		0	2	3	4	5
	0.25		0	1	3	4	5
	0.1		0	14	14	14	5
Fraction A$_1$ residue of the paste	1	3	0	0	0	0	5
A after dialysis	0.5		0	1	6	8	5
	0.25		0	6	15	15	5
	0.1		0	14	30	30	5
Fraction A$_2$ dialyzate of paste A	1	3	0	23	33	33	5
	0.5		0	23	30	30	5
	0.25		0	24	26	26	5
	0.1		0	34	34	34	5
Fraction B$_1$ liquid dialyzed, left	1	1	0	15	30	30	4.5
in residue	0.5		0	15	30	30	4.5
	0.25		0	18	35	35	4.5
	0.1		0	32	34	34	4.5
Fraction B$_2$ dialyzate	1	1	0	4	17	17	4
	0.5		0	11	30	30	4
	0.25		0	26	34	34	4.5
	0.1		0	38	38	38	4.5
Control	1	4.5	0	96	96	96	4.5
Blank	1	4.5	0	0	0	0	4.5

*All fractions added to 15 ml nutrient agar media.

Also the $H_2S_5O_6$ may react with sulfurous acid forming tri-thionic and thio-sulfuric acid: $S_5O_6^= + 2\ SO_3^= \rightarrow S_3O_6^= + 2\ S_2O_3^=$ from which the tri-thionic acid slowly decomposes with H_2O into sulfuric and thiosulfuric acids. Further, it is known that an acidic condition stabilizes the tetra- and penta-thionic acids but not the tri-thionic acids. Thus, there is a chance of accumulation of penta-thionic acid with an expected toxic effect.

TABLE 3

Toxicity tests with thiosulfate solutions*

Volume of Na₂S₂O₃·5 H₂O (in ml)	Solution I—2.96% Na₂S₂O₃·5 H₂O No. of colonies				pH of media after addition of reagent
	6/12	6/14	6/17	6/28	
4	0	26	29	no increase in colonies, but covers	5.5
2	0	28	31	"	5.0
1	0	72	72	"	5.0
0.5	0	120	120	"	5.0

Volume of lactic acid (in ml)	Solution II—1.65% Na₂S₂O₃·5 H₂O and 0.7% lactic acid Volume of Na₂S₂O₃·5 H₂O (in ml)	No. of colonies 6/13	6/14	6/17	6/28	pH
4	4	0	0	0	0	4.5
2	2	0	11	34	covers	4.5
1	1	0	50	50	covers	4.5
0.5	0.5	0	68	68	covers	4.5

Volume of lactic acid (in ml)	Solution III—1.65% Na₂S₂O₃·5 H₂O and 1.4% lactic acid Volume of Na₂S₂O₃·5 H₂O (in ml)	No. of colonies 6/13	6/14	6/17	6/28	pH
4	4	0	0	0	0	3.5
2	2	0	0	2	extended	4.0
1	1	0	48	48	covers	4.0
0.5	0.5	0	80	80	covers	4.0
Control		0	103	103	covers	5.6
Blank		0	0	0	0	5.6

*All test solutions added to 15 ml agar media.

For studying the possible toxic effect of thiosulfate solutions, three solutions were prepared: Solution I—2.96 percent sodium thiosulfate alone. Solution II—1.65 percent sodium thiosulfate and 0.7 percent lactic acid. Solution III—1.65 percent sodium thiosulfate and 1.4 percent lactic acid.

The lactic acid and sodium thiosulfate were added to 15 ml Sabouraud Agar media and mixed before inoculating with the spores of *Penicillium* and *Aspergillus* spp.

Considering the toxicity test, shown in table 3, we found that for Solution I—Sodium thiosulfate·5 H_2O in 2.96 percent solution did not show complete inhibition of the growth of the colonies at any dilution; for Solution II—Sodium thiosulfate·5 H_2O in 1.65 percent solution mixed with 0.7 percent lactic acid, did show complete inhibition at a concentration of 4 ml of 1.65 percent sodium thiosulfate and 4 ml 0.7 percent lactic acid for a period of 15 days; and for Solution III—Sodium thiosulfate·5 H_2O in 1.65 percent solution mixed with 1.4 percent lactic acid did show a complete inhibition of the growth of the colonies at a concentration of 4 ml of 1.65 percent sodium thiosulfate and 4 ml of 1.4 percent lactic acid. Using 2 ml of thiosulfate and 2 ml of lactic acid, the media kept clean for a period of 4 days, when 2 colonies were counted on the 5th day. Using Solution II under the same conditions, 34 colonies appeared on the 5th day. These results support Riesenfeld theory in the formation of penta-thionic acid. The difference obtained here is not due to a decrease in the pH, as already shown by the present authors (1958).

SUMMARY

Two types of molds, *Penicillium* spp. and *Aspergillus* spp., isolated from ailing silages, were exposed to two types of solutions. One type was a mixture of tetra- and penta-thionic acids, which was prepared and separated into fractions by centrifugation and dialysis. The most toxic active fractions did not pass readily through the membrane and were located in fractions A and A_1, which kept the media free from colonies for 15 days.

The other mixture was thiosulfuric acid which in aequeous solution forms penta-thionic acid. Three solutions were tried; one was the sodium salt as sodium thiosulfate, 2.96 percent; the second was a mixture of sodium thiosulfate, 1.65 percent, and lactic acid, 0.7 percent; and the third was a mixture of sodium thiosulfate, 1.65 percent, and lactic acid, 1.4 percent. The second and third solutions which contained the free acid, kept the media free from colonies for 15 days.

A process was developed for the preparation and analysis of the fractions.

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SOIL AND PALEOSOL OF THE WARNOCK TERRACE

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Soils developed on terrace remnants at the 960 to 1020 ft level are being studied at several places in the upper Ohio drainage basin with a view of determining some of the early Pleistocene history of the region. The high level alluvium, covering the terrace in the Ohio Valley proper, is of sand and gravel, containing pebbles of crystalline rocks and is presumed to be of glacial outwash (Leverett, 1903, pp. 88–98; Hubbard, 1954, pp. 365–370). Some of this alluvium is found as high as 1060 ft elevation in Section 9, Wells Township, Jefferson County, Ohio, near Salt Run and Rush Run. The high level terrace, covered with alluvium from weathering of local rocks, occurs along tributary streams, from basins not known to be glaciated, and joins with the Ohio River terrace throughout the upper Ohio Valley.

FIGURE 1. Map of region of Warnock Terrace.

During soil survey work, the author found a soil of the tributary high level terrace formed on top of another soil, a buried paleosol, in an excavation $\frac{1}{4}$ mi northeast of Warnock along the road to Glencoe, Smith Township, Belmont

County, Ohio (St. Clairsville Ohio Quadrangle Map, U. S. Geological Survey), at an elevlation of 1040 to 1080 ft.   This may be useful evidence in determining some of the early Pleistocene history of the region, as geologic events which took place in the Upper Ohio Valley may also have affected deposits in the tributary valleys as well.

The soil and buried paleosol of the terrace near Warnock have apparently been formed from alluvium from weathering of local rocks.   The buried paleosol was formed on a terrace level apparently older than and buried by the high level terrace.   Since the later is the highest terrace of glacial origin or formed as a result of glaciation, it is probably of early Pleistocene age.   The evidence indicates that the terrace on which the buried paleosol developed was there before the region was invaded by outwash from glaciers.

This report will refer to the high level terrace remnant near Warnock as the Warnock Terrace.   It is part of a terrace that is found along McMahon Creek near Neffs, Stewartsville, Glencoe, Warnock and Lamira.
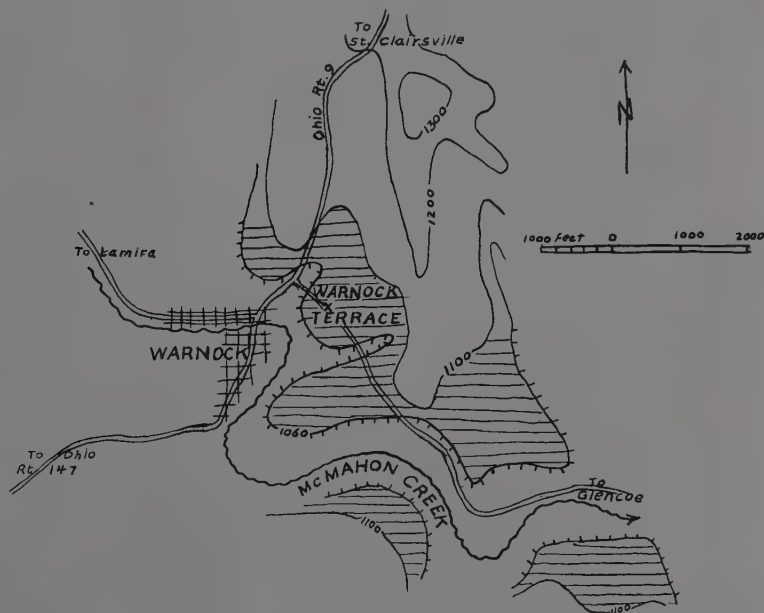

FIGURE 2.   Map of the Warnock Terrace.

TOPOGRAPHY OF THE WARNOCK TERRACE

The region near the Warnock Terrace has an upland surface which is a dissected part of the Unglaciated Allegheny Plateau.   The ridgetop remnants of this surface have a general elevation of 1200 to 1360 ft.   The preglacial drainage level stood at 1080 to 1040 ft in upper parts of tributary streams and descended to about 960 ft in the main valley at East Liverpool, Ohio.   It drained northward towards Lake Erie.

The rock terraces of this system are mentioned by Leverett (1903, pp. 88–98, 121–125).   During Pleistocene time this drainage level was entrenched and present stream levels are at 920 ft at Warnock and at 610 ft at Wheeling.

The upland soils are formed from interbedded sandstone, shale and limestone. Most of these soils, upstream from Warnock, are deep, medium to fine textured soils and most of them are formed partly from limestone.

SOIL AND BURIED PALEOSOL OF THE WARNOCK TERRACE

The soil of the Warnock Terrace has been identified by the author as Monongahela Silt Loam and the buried paleosol as a paleo-Humic-Gley soil. Both the soil and the paleosol are developed from alluvium from weathering of local, residual, sandstone, shale and some interbedded limestone rocks.

Location: NW ¼ Section 18, Smith Township, Belmont County, Ohio, along paved road from Warnock to Glencoe, ¼ mi northeast of Warnock and about 500 ft east of intersection with Ohio Route 9.

Slope: 3%, concave, 200 ft from base of steep slope.

Elevation: 1060 ft.   Relief: ridgetops at 1320 ft, stream at 920 ft.

Drainage: moderately well drained tending towards imperfectly drained class.

Collectors: John Dunlavy and H. D. Lessig.

(The soil descriptive terminology used below follows usage of the Soil Survey Manual by the Soil Survey Staff, 1951, U. S. Dept. of Agriculture, Handbook 18, Washington, D. C.)

Depth and Horizon	Profile Description (moist colors in Munsel notations, pH determined colorimetrically in field).
0–8 in. A_p	Dark grayish brown (10YR 4/2) silt loam; weak very fine crumb structure; friable when moist; no pebbles; very strongly acid, pH 4.8; boundary abrupt.
8–14 in. B_1	Brown (10YR 5/3) silt loam to silty clay loam with few faint reddish brown mottles; moderate fine subangular blocky structure; friable when moist; no pebbles; very strongly acid, pH 4.6; boundary abrupt, smooth.
14–20 in. B_{21x}	Yellowish brown (10YR 5/6) silty clay loam to silt loam with many medium prominent gray and reddish brown mottles; light yellowish brown (10YR 6/4) silty coatings on ped faces; weak medium prismatic structure breaking to moderate medium subangular blocky peds; friable when moist; small pebbles weathered to silt; strongly acid, pH 5.2; boundary clear, smooth.
20–45 in. B_{22g}	Strong brown (7.5YR 5/6) silty clay loam with many coarse prominent gray and reddish brown mottles and black Mn stains; light brownish gray (10YR 6/2) silty clay coatings on prism faces 4 mm thick; moderate very coarse prismatic structure breaking to very coarse angular blocky peds; firm when moist; no pebbles; strongly acid, pH 5.2; boundary gradual.
45–60 in. B_{23g}	Strong brown (7.5YR 5/6) silty clay with many coarse prominent gray and reddish brown mottles and black Mn stains; light brownish gray (10YR 6/2) clay coatings on prism faces 4 mm thick; moderate very coarse prismatic structure breaking to strong very coarse angular blocky peds; firm when moist, sticky when wet; no pebbles; very strongly acid, pH 5.0; boundary clear irregular extending in narrow pockets into underlying horizon.
60–65 in. A_{1b}	Very dark brown (10YR 2/2) coarse clay with many coarse faint dark gray (10YR 4/1) mottles; gray (10YR 5/1) fine clay coatings on prism faces 4 mm thick; weak coarse prismatic structure breaking to strong medium subangular blocky peds; firm when moist, plastic when wet; medium acid, pH 5.6; buried surface soil of paleo-Humic-Gley soil which has become part of solum of overlying soil.
65–120 in. B_{2b1}	Yellowish brown (10YR 5/6) silty clay loam with many fine distinct gray and brown mottles and black Mn stains; gray clay coatings on prism faces; moderate coarse prismatic structure breaking to fine subangular blocky peds; firm when moist; medium acid, pH 5.8; part of B horizon of paleo-Humic-Gley soil.

120–140 in.   Light gray (10YR 6/1) coarse silty clay 80% with light brownish gray (10YR
B_{2b2} 6/2) silt loam 20% in center of prisms, many coarse black Mn stains; moderate
             coarse prismatic structure; very firm when moist; medium acid, pH 5.8; part of
             B horizon of paleo-Humic-Gley soil.

140–160 in.   Strong brown (7.5YR 4/6) clay with many medium distinct gray mottles and
B_{3b} black Mn stains; moderate coarse prismatic structure; very firm when moist;
             medium acid, pH 6.0.

160 in.+   Gray (10YR 5/1) clay with brown stains in vertical cracks and black Mn stains;
D   extremely firm when moist; medium acid, pH 6.0; total thickness undetermined,
             however bedrock outcrops a short distance away, indicating this horizon is not
             very thick over bedrock.

TABLE 1

Mechanical analysis* of soil and Paleosol of Warnock Terrace

Depth	Horizon	Sand 2–.05 mm	Silt .05–.002 mm	Total clay <.002 mm	Fine clay <.0002 mm
0–8 in.	A_p	5.3%	73.7%	21.0%	5.2%
8–14	B_1	1.8	70.8	27.4	12.2
14–20	B_{21g}	2.3	69.1	28.6	13.0
20–30	B_{22g}	2.4	73.0	24.6	11.9
30–45	B_{22g}	3.0	61.0	36.0	17.0
45–60	B_{23g}	5.1	49.1	45.8	21.3
60–65	A_{1b}	3.0	23.4	73.6	38.5
65–80	B_{2b1}	10.3	46.4	43.3	19.6
80–100	B_{2b1}	13.0	50.4	36.6	12.2
100–120	B_{2b1}	11.4	47.1	41.5	13.3
120–140	B_{2b2}	10.2	43.7	46.1	16.0
140–160	B_{3b}	6.1	37.1	56.8	27.2
160–170	D	1.2	31.8	67.0	34.1

*Mechanical analysis made by the Ohio Agricultural Experiment Station, at Columbus, Ohio.

DISCUSSION

The soil of the upper 60 in. of solum of the Warnock Terrace is believed to be
derived from a more recent material and one laid down under different conditions
than the material of the paleosol, below 60 in. depth. The sand content of the
upper solum ranges from 1.8 to 5.1 percent while that of the paleosol ranges from
10.2 to 13.0 percent.

Horizon A_{1b} is called the A_1 horizon of the buried paleo-Humic-Gley soil
because of its dark color. The sand content of 3.0 percent is low compared to
the 10.2 to 13.0 percent sand content of the B_{2b1} and B_{2b2} horizons of the paleosol.
However, a Humic-Gley soil normally occurs in depressed positions and is developed
under high moisture conditions where clay sediment was probably deposited in
quiet water conditions. This could explain the high clay and low sand content.

The author believes the soil of the Warnock Terrace to be alluvium from
weathering of local rocks, deposited during the drainage cycle during which the
glacial outwash of the 1020 to 960 ft terrace of the Ohio Valley was deposited be-
cause both materials occupy the same general level where they join. However,
the alluvium of the Warnock Terrace and other tributary terraces, in basins not
known to be glaciated, differs from that of the Ohio Valley in that it is medium
to fine textured while that of the Ohio Valley is coarse textured and the later
contains pebbles of crystalline rocks. The terrace in the Ohio Valley apparently
belongs to the outwash of the earliest Pleistocene glaciation of the Allegheny

Plateau because of its 1020 to 960 ft elevation, presence of crystalline pebbles and greater weathering than other, lower level, glacial outwash material.   The soil of the Warnock Terrace is believed to be a part of that terrace, though of different material.

Buried paleosols have not been found beneath the 1020 to 960 ft outwash material of the upper Ohio Valley, except at one place about $1\frac{1}{2}$ mi southeast of New Cumberland, W. Va., where the lower part of what is thought to be a paleosol occurs beneath a solum developed in sand and gravel.   It is believed that the preglacial alluvial soil of the Ohio Valley was mostly removed by glacial meltwater transgressing and lowering a divide south of Bellaire.   Such meltwater was confined, in this vicinity, to the Ohio Valley and the ponded water in the valley of McMahon Creek did not remove the paleosol at Warnock but deposited other alluvium on top of it.

The entire soil profile of the Warnock Terrace is composite because the soil forming processes taking place in the B_2 horizon are extending downward through the A_{1b} horizon of the paleosol.   This is evidenced by the coarse prismatic structure of the B_{23g} horizon also occuring in the A_{1b} horizon and by the gray color developing along the prism faces.   The very dark brown color in the center of the prisms is the fossil remnant of the color of the former surface soil before it was buried.

CONCLUSIONS

The arrangement of the soil and paleosol of the Warnock Terrace shows that a geological event must have ponded the drainage of McMahon Creek so that alluvium was deposited over a former surface standing at 1055 ft elevation.   This ponding is interpreted as caused by glacial blocking of original northward drainage of a larger stream to which McMahon Creek was a tributary.   The deposit of the Warnock Terrace is correlated with the highest glacial outwash terrace in the upper Ohio drainage basin.   The ponding was caused by the advance of an early ice sheet to the Allegheny Plateau.

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THE EXPERIMENTAL PRODUCTION OF THE STRESS PICTURE WITH CORTISONE AND THE EFFECT OF PENICILLIN IN YOUNG CHICKENS†

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It is generally accepted that antibiotics will stimulate growth rate in chickens. Several theories attempting to explain this stimulation have been advanced. These include effects on intestinal flora, atypical bacteria, and the endocrines (Freerksen, 1956). A multitude of general and vague statements have been made in the popular poultry literature indicating the antibiotic as an "anti-stress" agent. Since stress "is a state manifested by a specific syndrome which consists of all the nonspecifically induced changes within a biological system" (Selye, 1956), an "anti-stress" agent is an agent that could prevent the conditions of this definition. An "anti-stress" agent could perform its function directly or indirectly, the former by eliminating the harmful organism or stressor agent and the latter by interfering with the cortical hormones released as a result of the stress response. The primary objective of this experiment was to determine the effect of penicillin in the presence of exogenously administered cortisone acetate.

PROCEDURE

The body weight, tissue and white blood cell counts of 72 New Hampshire females were studied from 9 days of age to 37 days of age under four separate treatments. The four treatments consisted of the following: penicillin only, PO; penicillin plus cortisone, PC; basal only, BO; and basal+cortisone, BC. These treatments were randomly assigned to the top four decks of each of 3 batteries. All treatments were, therefore, replicated three times. There were six birds in each deck. The basal diet which was free of medication was fed to all decks for the first nine days after hatching. At this time an initial total and differential white cell count was made of five birds per deck. The Natt-Herrick (1952) technique was employed for the total count and Wright's stain for the differential count. Beginning at 9 days of age penicillin—50 gm/1,000 lb—was added to the feed of the designated groups. One injection of 5 mg of cortisone acetate—0.1 cm^3—was administered to the PC and BC groups at 23 days of age. All groups were bled 3 hours later. At 30 days of age all groups were again bled. Cortisone acetate—5 mg per injection—was administered daily from the thirty-first to the thirty-sixth day of age to the PC and BC groups. All groups were then bled 24 hours after the last injection. It should be noted that a saline control was not employed even though cortisone is suspended in saline solution. According to the recent data of Glick (1958a), a single injection of 0.5 cm^3 saline or multiple injections of 0.1 cm^3 saline will not produce the decrease and increase in lymphocytes and heterophiles, respectively, which characteristically occur following the injection of cortisone acetate. Immediately after bleeding, all birds were killed and their adrenals, thyroids, and bursa were weighed and prepared for later histological examination. Body weights and white blood cell counts were analyzed by the analysis of variance. The analysis of covariance was employed in analyzing the gland weights. Standard errors were calculated for each mean. The statistical procedures were from Snedecor (1946) and Duncan (1955).

RESULTS

The white cell counts are reported in tables 1, 2, and 3. Each mean is based

on 15 birds. At the start of the experiment none of the white blood cell counts
differed significantly, 9–day-old counts. The addition of penicillin to the ration
from the ninth to the twenty-third day did not significantly affect the total white
blood cells, lymphocytes or heterophil counts (tables 1, 2, and 3). However, the
injection of 5 mg of cortisone three hours before bleeding significantly increased
total white blood cells, relative and absolute counts of heterophiles, and decreased
significantly the percent lymphocytes. The groups receiving penicillin plus
cortisone (PC) and basal plus cortisone (BC) were about equally affected by the
cortisone injections. There is some indication from the data that the decline in
lymphocytes and increase in heterophiles were not as extreme in the PC groups
as in the BC groups from the ninth to the twenty-third day (tables 2 and 3).
However, too much emphasis should not be placed on this point since two weeks
had lapsed from the initial bleeding and differences between the PC and BC
groups were not significant. At 30 days of age or one week after one injection of
cortisone all groups were bled. The counts were determined to ascertain if the
groups receiving cortisone had recovered from their initial stress response.
There were no significant differences between the means for total white
blood cells, lymphocytes, or heterophiles. That the total counts were not
lowered in the PC groups was interesting. There was a trend at 30 days of age
for higher lymphocytes and lower heterophil counts in the PO groups as compared
to the BO groups. These differences were not significant. From the thirty-first
to the thirty-sixth day, cortisone was administered to the designated groups at
the level of 5 mg per day (tables 1, 2, and 3). Twenty-four hours after the last
injection, the mean total and relative and absolute heterophil counts for the
cortisone groups were 7000 cells mm³, 15 percent, and 7000 cells mm³, respectively,
higher than the controls. Also, the mean percent lymphocyte count was 17
percent lower than the control group. All the differences were highly significant
at the one percent level. The presence of penicillin apparently had little influence
in altering the course of the cortisone injections. However, it should be pointed
out that the decrease and increase in percent lymphocyte and percent and absolute
heterophiles, respectively, were less extreme in the penicillin groups.

The effect of penicillin plus cortisone on the adrenal, thyroid, and bursa weights
is presented in table 4. The data were analyzed by the analysis of covariance.
The mean adrenal weight of PC and BC was significantly less than the PO and BO
groups. The mean adrenal weight of the PO group was significantly heavier than
the BO group. The depressive effect of cortisone on the adrenal gland is no
doubt a result of the supression of ACTH production by the anterior pituitary
(Ingle, 1938). The stimulating effect of penicillin on the adrenal is not as easily
explained. The mean thyroid weights for the four treated groups did not differ
significantly. The heaviest thyroids were in the penicillin groups (viz., PO).
Cortisone markedly reduced the mean weight of the bursa of Fabricius. Penicillin
was unable to protect the bursa against the regressive processes of cortisone
acetate. The mean weight of the PO group was heavier than the BO group. The
difference was not significant.

Table 5 summarizes body weight gains for the four treatment groups. The
groups did not differ significantly in weight gains from the ninth to the thirtieth day.
The injection of cortisone during the thirtieth to thirty-seventh day of age sig-
nificantly reduced weight gain in both BC and PC groups. The PO and BO
groups at this time did not differ significantly. Apparently penicillin was unable
to protect the bird against the catabolic action of cortisone at the levels injected.

DISCUSSION

The injection of birds with cortisone acetate markedly reduces the relative
lymphocyte and increases the relative and absolute heterophil counts (Bannister
1951; Huble, 1955; and Glick, 1958a). The results of this test in respect to

cortisone are then in agreement with the avian literature (tables 1, 2, and 3). The addition of procaine penicillin was unable to alter significantly the cortisone produced decrease in lymphocytes and increase in heterophiles. Our data, then, concur with Meites (1952) who reported that an antibiotic in the diet of male rats was unable to prevent the eosinopenic response to cortisone. Since cortisone probably acts directly on the lymphocyte (Dougherty, 1952), an agent that could counteract the effect of injected cortisone would have to interfere directly with the hormone itself, or act as a protector or stimulator at the cell level. Obviously, since cortisone markedly reduced the lymphocyte percent even in the presence of penicillin, neither of our postulates occurred. In the presence of a stressor agent (e.g., an atypical bacterium), glucocorticoids (e.g., cortisone) would be produced by the adrenal cortex (Selye and Heuser, 1956). An antibiotic in the ration would act on the particular stressor agent and thus prevent the stress response. The results would be a lymphopenia in the birds not fed antibiotics and a relatively higher lymphocyte count in the antibiotic fed birds. This explanation may account for part of the white cell increase reported by Glick (1958b) with penicillin.

TABLE 1

The influence of procaine penicillin and cortisone on total white blood cells at various ages in New Hampshire females[1]

| | Treatment groups | | | |
	PC	BC	PO	BO
9-day-old	14.2±1.5	13.4±1.1	13.4± .77	12.8±1.0
23-day-old	27.6±2.8	26.2±1.5	18.8±1.1	21.0± .9
30-day-old	27.4±1.6	20.6±1.6	23.4±2.3	24.0±1.5
37-day-old	32.0±1.4	32.0±1.5	23.5±1.3	26.8±1.3

[1]Cells/mm³ (x1000) ± S.E.
Means not underscored by the same line differ significantly (P<.01) (Duncan, 1955).

Meites (1951, 1952) reported that aureomycin was partially able to counteract the body and thymus weight depression of cortisone acetate. The results of this paper indicate that in the chicken procaine penicillin was unable to prevent the body weight and bursa weight depression which accompanies the injection of large doses of cortisone (tables 4 and 5). It is interesting that the largest bursae were in the PO group. Although the difference between the PO and BO groups was not significant, the results corroborate a past report (Glick, 1957) where significantly larger bursae resulted in the presence of penicillin. According to a review paper (Dougherty, 1952), the thyroid appears to have a slight stimulator effect on certain lymph structures. This might explain the larger bursae of the PO group since the mean thyroid weight was heaviest in this group. In order to verify the thyroid data, a histometrical analysis was made of six thyroids from each group. The height of one epithelial cell in each of four follicles per thyroid was measured under oil immersion with an ocular micrometer. The means and their standard errors are presented in table 6. The histometrical procedure indicated that the PO group may have the most active thyroid. It also rearranged the remaining three groups into the same order as their respective mean bursa weights. The increase in chick thyroid size in the presence of procaine penicillin verifies the work of Draper and Firth (1957).

TABLE 2

*The influence of procaine penicillin and cortisone on lymphocytes
at various ages in New Hampshire females*

	Treatment groups			
	PO	BO	PC	BC
Relative ± S.E.				
9-day-old	79 ±3.7	79 ±2.7	79 ±2.3	82 ±2 5
23-day-old	72 ±2.7	69 ±8.3	61 ±6.4	54 ±4.8
30-day-old	79 ±2.7	76 ±2.1	74 ±5.3	75 ±3.8
37-day-old	76 ±1.8	76 ±2.4	61 ±4.2	57 ±3.4
Absolute x 1000 ± S.E.				
9-day-old	10.5±1.7	10.2±1.4	11.2±1.8	10.7±1.6
23-day-old	13.5±1.2	13.9±1.4	15.6±2.2	14.1±1.7
30-day-old	18.4±2.4	17.9±1.8	20.1±2.3	15.0±1.5
37-day-old	17.9±1.7	19.0±2.4	18.8±1.8	18.3±1.8

Means not underscored by the same line differ significantly (P<.01) (Duncan, 1955).

TABLE 3

*The influence of procaine penicillin and cortisone on heterophiles at
various ages in New Hampshire females*

	Treatment groups			
	BC	PC	BO	PO
Relative ± S.E.				
9-day-old	12 ±2.8	14 ±2.4	14 ±2.9	12 ±4.0
23-day-old	40 ±4.7	35 ±6.5	25 ±5.2	21 ±2.2
30-day-old	17 ±3.3	18 ±3.5	17 ±1.9	14 ±2.1
37-day-old	32 ±2.7	31 ±4.3	14 ±1.6	15 ±2.2
Absolute (x1000) ± S.E.				
9-day-old	1.6±.64	1.8±.46	1.6±.37	1.5±.54
23-day-old	10.4±1.0	10.6±1.3	5.6±.79	3.8±.60
30-day-old	5.4±1 1	4 9±1 3	4 3± 8	3 2± 61
37-day-old	10.5±1.8	10.9±3.2	3.4±1.3	3.6±.74

Means not underscored by the same line differ significantly (P<.01) (Duncan, 1955).

TABLE 4

A comparison of the effect of penicillin and cortisone on the adrenal, thyroid, and bursa weights of 37-day-old New Hamshire females[1]

	PO	BO	PC	BC
Adrenal—grams	.0607 ± .0029	.0521 ± .0024	.0454 ± .0049	.0430 ± .0023
Thyroid—grams	.0481 ± .0035	.0410 ± .0035	.0431 ± .0046	.0409 ± .0040
Bursa—grams	.6058 ± .0596	.5201 ± .0546	.3257 ± .0409	.3753 ± .0400

[1]Eighteen birds per group.
Means not underscored by the same line differ significantly (Duncan, 1955).

TABLE 5

A comparison of the effect of penicillin and cortisone on gain in body weight of New Hampshire females[1]

Gain in grams between	Treatment groups			
	PO	BO	BC	PC
9–23 days of age	208 ± 20	205 ± 8	184 ± 8	207 ± 9
23–30 days of age	118 ± 8,	118 ± 9	115 ± 9	109 ± 8
30–37 days of age	163 ± 14	152 ± 18	78 ± 8	68 ± 17

[1]Eighteen birds per group.
All means not underscored by the same line differ significantly (Duncan, 1955).

TABLE 6

Histometrical determination of the thyroids of 37-day-old New Hampshires

Treatment	Epithelial height in microns
Penicillin (PO)	6.27 ± .48
Basal (BO)	5.50 ± .43
Basal+cortisone (BC)	5.18 ± .25
Penicillin+cortisone (PC)	5.04 ± .28

Inhibition of ACTH production as a result of cortisone administration results in adrenal atrophy (Ingle, 1938). In the cockerel and capon, Dulin (1955) was unable to produce adrenal atrophy with twenty 1,000μg doses of cortisone. However, he was able to suppress the adrenal enlargement accompanying epinephrine with cortisone injections. Dulin postulated that the chick adrenal may be slightly independent of pituitary stimulation. The data in table 4 clearly demonstrate that 6 daily injections of 5 mg of cortisone will significantly reduce adrenal weight.

The total amount of cortisone injected exceeded Dulin's by 10 mg. It was obvious from the histological examination that chromaffin cells were in excess of the interrenal cells in the adrenals of cortisone injected birds. We were unable to measure accurately the amount of each cell type in the four groups. The largest mean adrenal weight was in the PO group. Since the largest mean bursa weight was also found in this group, it might suggest that penicillin is able to protect the bursa from slight endogenous increases in adrenal hormones.

SUMMARY

The addition of procaine penicillin to a basal ration —50 gm per 1,000 lb— did not prevent the characteristic decrease in lymphocytes, increase in heterophiles and bursa regression in the presence of cortisone acetate.

Cortisone significantly decreased the weight of the adrenal and bursa of Fabricius. The addition of procaine penicillin significantly increased the weight of the adrenal and bursa. The heaviest mean thyroid was also found in the penicillin group. Penicillin did not affect gain in body weight. Cortisone significantly reduced body weight gains.

ACKNOWLEDGMENT

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TWO NEW SPECIES OF *CTENICERA*

(COLEOPTERA: ELATERIDAE)

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The following two forms are sufficiently different from described species to warrant names.

Ctenicera mertoni n. sp.

Male.—Robust, shining black throughout, clothed with short recumbent dark pubescence.

Head broadly depressed on front; surface densely, coarsely punctured; eyes small; antennae extending one segment beyond hind angles of pronotum when laid along side, second and third segments with scattered fine punctures, remaining segments densely finely punctured, segments 4 to 10 inclusive serrate.

Pronotum wider than long, widest across hind angles, wider at base than at apex; apical margin sinuate, median lobe broad; basal margin sinuate; lateral margin broadly rounded in front, sinuate back of middle, hind angle slightly divergent, apex truncate; disk convex, hind angles carinate, surface coarsely, densely punctured, punctures more numerous toward sides.

Elytra with disk convex; sides subparallel back of humeri, expanded back of middle, then broadly rounded to sutural margin; surface striate, punctures of striae coarse, interspaces densely, finely punctate.   Scutellum densely finely punctate.

Beneath abdomen densely finely punctate.

Length 10.3 mm; width 3.9 mm.

Female.—Differs from ♂ by antennae not reaching hind angles of pronotum when laid along side.

Holotype ♂ and allotype from 13 miles west of Mineral, Tehama Co., California, July 9, 1954; two paratypes from 15 miles west of Mineral, June 25, 1948, all collected by D. J. and J. N. Knull.   Holotype, allotype and paratype in collection of author, paratype in collection of M. C. Lane to whom I am indebted for comparison of specimens.

This species runs to *Ctenicera glauca* (Germ.) in Brown's key (1936).   It can be separated by the dark vestiture and structure of ♂ genitalia, and is named for Merton C. Lane.

Ctenicera dorothyae n. sp.

Male.—Narrow, elongate, size and form of *C. tarsalis* (Melsh.); color of head, pronotum, scutellum and ventral surface shining dark brown; legs, hind angles of pronotum and elytra yellowish brown, darker along suture and outer margin of each elytron.

Head somewhat flattened, clypeal margin raised above antennae, not depressed in middle; surface coarsely, closely punctured, umbilicately in middle, pubescence not dense; antennae extending over one segment beyond hind angles of pronotum, segments 3 to 10 inclusive strongly serrate.

Pronotum longer than wide, widest back of middle, wider at base than at apex; anterior margin broadly sinuate, median lobe faint; lateral margin rounded at apex, then divergent to back of middle, sinuate near base; hind angles broadly rounded, slightly diverging; disk convex, prehumeral carina lacking; surface punctures fine and separated by more than their own diameters in middle, closer, larger and umbilicate on sides, recumbent pubescence short, similar to that of head.   Scutellum heart-shaped, densely punctured, pubescent.

Elytra elongate, widest about middle; side margins rounded near base, subparallel to back of middle then broadly rounded to suture; disk somewhat flattened, a basal depression each side; surface coarsely striately punctate, punctures separated by much less than their own diameters, intervals convex, densely minutely punctate, recumbent pubescence short.

Beneath sides of abdomen densely finely punctate, punctures more widely separated in middle.

Length 10.3 mm; width 2.9 mm.

Female.—Differs by pronotum being much wider and antennae not extending to hind angles of pronotum when laid along side.

Holotype ♂ and allotype collected in Hocking Co., Ohio, May 14, 1954 by D. J. and J. N. Knull. Paratypes as follows—OHIO: Hocking Co., April 20, May 1, 22, 1938; April 30, May 2, 7, 1939; May 23, 1947; April 24, 1951; April 14, May 5, 1954; May 15, 1956, all D. J. and J. N. Knull; Jefferson Co., R. J. Sim; Holmes Co., May 26, 1935, R. T. Everly; Ashtabula Co., May 5, 1937, R. T. Everly; Franklin Co., June 29, 1939; Wooster, May 7, 1914 and June 29, 1939. PENNSYLVANIA: Castle Rock, May 19, H. W. Wenzel; Delaware Co., H. W. Wenzel Collection; Dauphin, May 20; Chambersburg, April 25; Laporte, June 2, 1930; Forksville, May 31, 1931; Sullivan Co., May 20, 1930, June 3, 1930, June 3, 1932, June 3, 1933, all J. N. Knull.

NEW JERSEY: Westville, May 6, H. W. Wenzel. MARYLAND: Beltsville, May 5, 1934. CONNECTICUT: Orange, June 4, 1910, A. B. Champlain. NEW HAMPSHIRE: Charleston, June 17, 1937, M. C. Lane; Durham, May 20, R. L. Blickle. MASSACHUSETTS: June 27, 1941, R. C. Osburn. MAINE: June 12, 1909, C. A. Frost; Meddybemps, June 22, 1922, R. J. Sim; Lincoln Co., June 14, 1938, D. J. Borror; Monmouth, June 21, 1910, C. A. Frost. CANADA: New Brunswick, May 25, 1922, J. N. Knull.
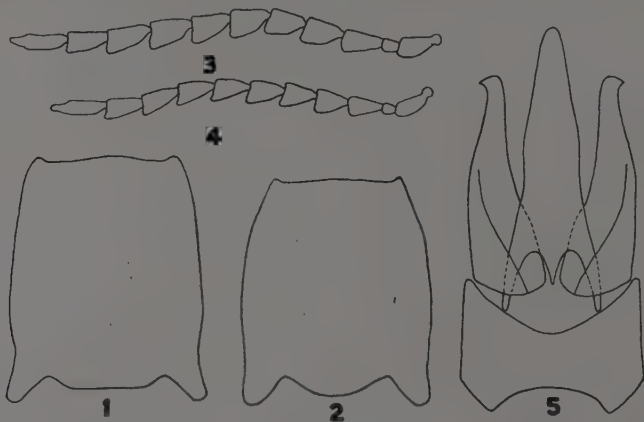
Ctenicera tarsalis (Melsh.)   *Ctenicera dorothyae* n. sp.   *Ctenicera mertoni* n. sp.

    1. ♂ pronotum   2. ♂ pronotum   5. ♂ genitalia
    3. ♂ antenna   4. ♂ antenna

This species is mixed with *C. tarsalis* (Melsh.) in collections. Melsheimer (1846) states, "With the clypeus short, slightly impressed, impression extending to the middle of the vertex, with the anterior edge slightly elevated in front of the eyes, and indented in the middle. . . . Thorax oblong—subquadrate." Clypeus of *dorothyae* is not indented.

In *dorothyae* ♂ antennae extend a little over one segment beyond hind angles of pronotum. In *tarsalis* they extend two segments beyond this point. Median pronotal punctures umbilicate in *tarsalis*. The shape of the pronotum is different as seen in figure. ♂ genitalia are also different.

It is named for my wife, Dorothy Johnson Knull, who collected with me many years and aided in my studies.

Holotype ♂, allotype and paratypes in Collection of author. Paratypes in Collections of The Ohio State University, Museum of Comparative Zoology and M. C. Lane.

Through the kindness of Dr. P. J. Darlington, Jr., I have been able to designate a ♂ speci-
men in the Melsheimer Collection, Museum of Comparative Zoology, Cambridge, Mass., as the
lectotype of *Ctenicera tarsalis* (Melsh.).   The specimen bears no locality label, however Melsheimer
states that his material came from Pennsylvania.

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A FLORISTIC STUDY OF A SOUTHERN ILLINOIS SWAMPY AREA

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In the western part of Union County in southwestern Illinois is a unique area
of swamps and woodlands of low ground.   This paper is an endeavor to discuss
floristic relationships of the species of vascular plants which occur in this area.

These swamps of Union County occur in the following sections of T 11 S,
R 3 W: 9, 16, 17, 21, 28, and 33.   A small portion of T 12 S, R 3 W, sections
3 and 4 is also included (fig. 1).   Within this area, numerous habitat types are
found.   This study deals only with the floristics of the swamp-inhabiting plants.
A high range of hills forms the eastern border of the swamp.   At the western
limits of these hills, massive limestone bluffs which once bordered the Mississippi
River are exposed.   These often nearly vertical bluffs are in places almost 350 feet
high.   They are dissected by numerous east-west ravines which are covered with
dense vegetation.   Hill prairies are located along the western-facing edges of
many of these bluffs.   These treeless areas are minute replicas of prairies to the
west.

The swamp vegetation is found in an area from one-eighth of a mile to nearly
a mile wide and for a length of about six miles.   The southern end of the area is
occupied by a finger-shaped lake known as Wolf Lake.   The lake extends for
nearly two miles, becoming shallower at its northern end where it gives rise to a
deep swamp.   For convenience of study, the area has been divided into three
regions: Wolf Lake, Wolf Lake Swamp, and LaRue Swamp.

DESCRIPTION OF THE THREE AREAS
Wolf Lake

Wolf Lake (fig. 2) is a finger-shaped body of water located northeast of the
village of Wolf Lake, Union County, Illinois.   It extends for nearly two mi and
is 350 ft across at its widest point with a maximum depth of about 20 ft.   It
becomes progressively more shallow and narrow at its northern extremity and
gives way to a swamp called Wolf Lake Swamp.   Wolf Lake is an old channel
of the Big Muddy River.

Dense patches of vegetation surround Wolf Lake, particularly where it gives
rise to Wolf Lake Swamp.   No trees grow in the lake proper, but several encroach
upon the borders.   The red maple (*Acer rubrum*) and swamp cottonwood (*Populus
heterophylla*) are predominant along the shore, while red ash (*Fraxinus pennsyl-*

vanica), honey locust (*Gleditsia triacanthos*), and silver maple (*Acer saccharinum*) occur occasionally. Buttonbush (*Cephalanthus occidentalis* and its variety *pubescens*) often forms thickets along the shore, frequently occurring in shallow water. It is exceedingly abundant in the transition zone between Wolf Lake and Wolf Lake Swamp.

Along the shore of Wolf Lake are numerous rooted herbs. The swamp mallow (*Hibiscus lasiocarpus*) is common, particularly at the southern end of the lake. Species of beggar's-ticks (*Bidens* spp.) are abundant. Occasional plants of water dock (*Rumex verticillatus*), aster (*Aster simplex* and *A. vimineus*), and cardinal-flower (*Lobelia cardinalis*) may be encountered. Several sedges occur in clumps along the shore—*Carex frankii*, *C. squarrosa*, *C. typhina*, *C. vulpinoidea*, *Cyperus erythrorhizos*, and *Cyperus ferruginescens*. The species of shore grasses are fewer in number, but where grasses occur, they form dense stands. These shore grasses include species of barnyard-grass (*Echinochloa* spp.), species of cutgrass (*Leersia* spp.), Munro grass (*Panicum agrostoides*), and creeping bent-grass (*Agrostis palustris*). Scattered carpets of pony grass (*Eragrostis hypnoides*) are known.

A short distance from the shore, but growing in the shallow water of Wolf Lake, are several coarse but attractive herbs. These include pickerel-weed (*Pontederia cordata*) (fig. 5), arrowleaf (*Sagittaria latifolia*), American lotus (*Nelumbo lutea*), watershield (*Brasenia schreberi*), American water-lily (*Nuphar advena*) (fig. 7), fragrant water-lily (*Nymphaea odorata*), sweet flag (*Acorus calamus*), and arrow-arum (*Peltandra virginica*). Mild water-pepper (*Polygonum hydropiperoides*) is very common. In deeper waters where fewer species are found, pond-weed (*Potamogeton diversifolius*), coontail (*Ceratophyllum demersum*), cabomba (*Cabomba caroliniana*), and naiad (*Naias flexilis*) are most frequent. A few free-floaters, many of them exceedingly rare in Illinois, exist in more or less stagnant waters near the shore. Numbered among these are watermeals (*Wolffia columbiana* and *Wolffiella floridana*), duckweeds (*Lemna minor* and *Lemna perpusilla*), *Spirodela polyrhiza*, and sponge-plant (*Limnobium spongia*) (fig. 3).

There are a few disturbed areas along the shore, caused primarily by fishermen who frequent their favorite fishing spots. In these disturbed areas, the small-flowered morning-glory (*Ipomoea lacunosa*) often completely over-runs the other species. Occasional plants of heliotrope (*Heliotropium indicum*) may be found.

Wolf Lake Swamp

Where Wolf Lake becomes narrower and shallower at its northern limit, Wolf Lake Swamp originates. The northern border of this swamp arbitrarily is set at the road which extends from Illinois Route 3 eastward to the base of the massive limestone bluffs known as the Pine Hills. These bluffs form the eastern limit of the swamp. To the west, a gradual rise in elevation is responsible for the dissipation of the swamp into a low woodland area.

A large portion of Wolf Lake Swamp is inundated throughout the year. Along its periphery, the area is covered by water for only a part of each year.

In the constantly inundated area, the standing water varies from one in. or so at time of lowest water to about five ft in depth. Different groupings of plants are recognized with relation to the depth of water in the swamps. In areas which may become covered by five ft of water, buttonbush is most abundant. Trees are numerous, but only a small percentage of them are living. Among the trees present are black willow (*Salix nigra*), swamp cottonwood, and red maple. Occasional plants of pondweed and naiad are found. Growing as an epiphyte on the bases of some of these trees is the water horehound (*Lycopus rubellus*).

In water that sometimes is two ft deep, large monocotyledonous perennials such as sweet flag, arrow-leaf, arrow-arum, and bur-reed (*Sparganium eurycarpum* and *S. androcladum*) are common (fig. 9). Trees are more abundant where the water is shallower. Pumpkin ash (*Fraxinus tomentosa*), red maple, swamp cotton-

wood, water locust (*Gleditsia aquatica*), and honey locust are rather common. Coarse sedges abound in this shallow water area. Numbered among these are *Carex lupuliformis, Carex lurida, C. hystricina, C. lupulina*, and *C. stipata*. Free-floaters present are sponge-plant, watermeal, species of duckweed (*Lemna trisulca* and *L. minor*), and mosquito fern (*Azolla mexicana*).

A distinct woodland community of low ground, in which the area is inundated for only a portion of each year, exists in the outer regions of the swamp. Tree composition is somewhat different from the swamp proper. Swamp cottonwood, red maple, and honey locust still occur, but in smaller numbers. With these are silver maple, pin oak (*Quercus palustris*), box elder (*Acer negundo*), and sweet gum (*Liquidambar styraciflua*) in appreciable numbers while occasional plants of slippery elm (*Ulmus rubra*), swamp chestnut oak (*Quercus prinus*), and white oak (*Quercus alba*) occur. Only gray dogwood (*Cornus obliqua*) and Virginia willow (*Itea virginica*) are found in the shrub layer. The understory is sparsely populated, but a large variety of species occurs. Most abundant are pink St. John's-wort (*Triadenum walteri*), hydrolea (*Hydrolea affinis*), water parsnip (*Sium suave*), monkey-flower (*Mimulus alatus*), and bedstraw (*Galium obtusum*). Gerardia
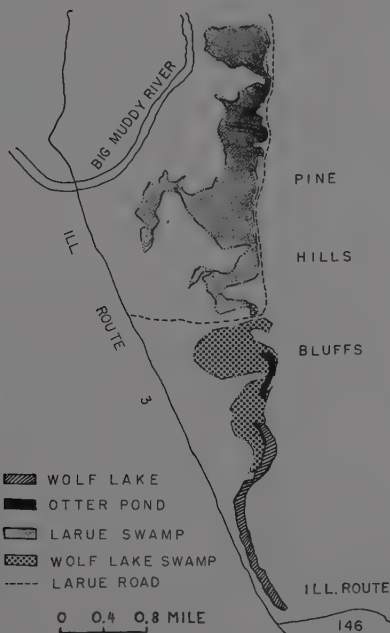
FIGURE 1.　Map of the study area in southwestern Illinois.

(*Gerardia tenuifolia*), butterweed (*Senecio glabellus*), swamp milkweed (*Asclepias perennis*), and enchanter's nightshade (*Circaea latifolia*) are less common. Rare species are skullcap (*Scutellaria nervosa*) and bishop's-weed (*Ptilimnium costatum*). All except butterweed flower during the summer and fall.

Near the base of a limestone bluff in T 11 S, R 3 W, section 18 is an area of deeper water. This is called Otter Pond. The borders are thickly populated with buttonbush and Virginia willow.

LaRue Swamp

North of the road extending from Illinois Route 3 to the Pine Hills is the southern end of the LaRue Swamp (fig. 4, 6, 8). This swamp, also bounded to the east by limestone bluffs, is much more extensive than the Wolf Lake Swamp. It covers an area nearly two-and-three-fourths mi long and from one-eighth to one mi broad. It is fed by refreshing limpid springs which are at the base of the limestone bluffs. Colonies of beavers live in LaRue Swamp. The presence of their dams across the swamp results in the constant back-up of the water. In more quiet areas where the water seldom is in motion, stagnation frequently occurs. The animals of this swamp (termed the Pine Hills Swamp), particularly the fishes, have been discussed by Gunning and Lewis (1955).

As it emerges from the springs the water has a temperature the year around between 56° and 58° F (Gunning and Lewis, 1955). In the rapidly flowing water at the springhead, only water-cress (*Nasturtium officinale*) thrives. In adjacent areas where there is moderate water movement resulting from the rapid currents of the spring's main channel, additional species occur. These, for the most part, are species which also inhabit the borders of streams in southern Illinois. Included here are ditch stone-crop (*Penthorum sedoides*), water plantain (*Alisma plantago-aquatica* var. *parviflorum*), pink swamp milkweed (*Asclepias incarnata*), and mild water pepper, along with manna grass (*Glyceria septentrionalis*) and sedge (*Carex vulpinoidea*). In a zone from three to 15 ft wide on either side of the spring's main channel is a unique community of plants. The area inhabited by these plants is inundated by one to six in. of water for most of each year. Unusually occurring species, many of which are found in no other place in the swamp, are in this zone. Among the rarer ones are bulrush (*Scirpus validus*), two grasses (*Glyceria pallida* and *G. arkansana*), and American featherfoil (*Hottonia inflata*). Cat-tail (*Typha latifolia*) is common at this site.

The water from the spring flows into the area occupied by the beavers where it accumulates to a depth of nearly five ft. LaRue Swamp is constantly inundated in its more central areas, although toward the periphery, the water is shallower and the area is inundated only nine to ten months of the year. Beyond this, low swampy woods prevail and these, in turn, give rise on somewhat higher elevated areas to deep mesophytic woodlands. It is these rich woods that are the most prolific areas in southern Illinois for spring wild flowers. Scores of violets (*Viola* spp.), dutchman's-breeches (*Dicentra cucullaria*), bloodroots (*Sanguinaria canadensis*), wake robins (*Trillium recurvatum*), larkspurs (*Delphinium tricorne*), and numerous others abound. Since this community is not properly a swamp community, no further discussion of it will be pursued in this paper.

EXPLANATION OF FIGURES IN PLATE

2. Looking south along Wolf Lake. The large colonies of plants along the right shore of the lake include pickerel-weed (*Pontederia cordata*).
3. Sponge-plant (*Limnobium spongia*) and species of duckweed (*Lemna* spp.).
4. April in LaRue Swamp.
5. Pickerel-weed (*Pontederia cordata*) in Wolf Lake.
6. June in LaRue Swamp. Numerous sprouts of red ash (*Fraxinus pennsylvanica*) growing from old stumps.
7. *Nuphar advena* in a more shallow area of the swamp.
8. Late August in LaRue Swamp. Water surface is covered by many tiny free floating plants.
9. Bur-head (*Sparganium eurycarpum*) growing in LaRue Swamp. Water surface is densely covered with mosquito fern (*Azolla mexicana*). Damaged tree has resulted from the work of beavers.

(Figures 2, 3, 4, 5, 8, 9 by John W. Voigt, Southern Illinois University, Carbondale. Figures 6, 7 by Karl U. Kramer, University of Utrecht, Netherlands)
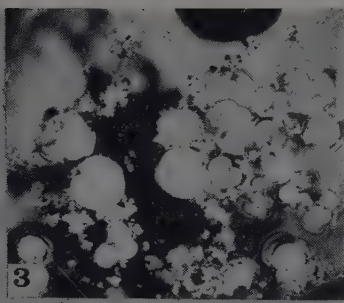
The constantly inundated regions of LaRue Swamp are similar to those of Wolf Lake Swamp except that more species exist in LaRue Swamp. Trees are common, with pumpkin ash clearly comprising 60 percent of those present. In moderate numbers are red ash, red maple, swamp cottonwood, southern hackberry (*Celtis laevigata*), and water locust. In the most remote parts of the swamp are a few scattered trees of bald cypress (*Taxodium distichum*) and Drummond's red maple (*Acer drummondii*).

Shrubs are plentiful in the standing water. Buttonbush again is encountered most frequently, but thickets of water willow (*Decodon verticillatus*) and swamp rose (*Rosa palustris*) become established locally.

Herbaceous members of the standing water community are not frequent, but those that are present usually have vivid flowers. Yellow water-crowfoot (*Ranunculus flabellaris*), water primrose (*Jussiaea decurrens*), water mustard (*Neobeckia aquatica*), and American featherfoil are particularly attractive. In more shallow water are the coarse monocotyledons. Some of these are *Carex lupulina*, *Carex lupuliformis*, *Carex retrorsa*, *Carex comosa*, *Carex stipata*, and *Carex crus-corvi*. Growing as epiphytes on the bases of pumpkin ash and southern hackberry are clumps of the cypress-knee sedge (*Carex decomposita*). A few small unusual herbs such as bladderworts (*Utricularia vulgaris* and *U. gibba*) and red iris (*Iris fulva*) occur. In the stagnated areas, free-floaters abound, among which are mosquito fern, duckweeds, watermeal, and sponge-plant.

The partly inundated periphery of LaRue Swamp contains species which also occur in other open moist habitats in southern Illinois. Spring flowering species include mousetail (*Myosurus minimus*) and Pennsylvania water cress (*Cardamine pennsylvanica*). Those which begin to flower in June are water dock, lizard's-tail, water parsnip, and bishop's-weed.

The swamp gives way to a woodland community on low ground which is essentially like the low woodland community bordering the Wolf Lake Swamp. Dominant trees are red maple, honey locust, and swamp cottonwood, with silver maple, sweet gum, and pin oak present in considerable numbers. Swamp holly (*Ilex decidua*) is the most frequently encountered shrub. The understory has the same composition as the Wolf Lake Swamp lowland woods except that the pink St. John's-wort and hydrolea are not as common in the former.

GEOGRAPHIC RELATIONSHIPS OF THE SWAMP SPECIES

In the swampy area treated in this study, eighteen species of trees, six species of shrubs, and three woody vines were encountered. Some of these grow almost exclusively in standing water; others seem to tolerate standing water for a small portion of each year; still those of the low woodland communities generally are not covered by water during any part of the year.

Woody Species of Constantly Inundated Areas

Acer drummondii	*Gleditsia aquatica*
Acer rubrum	*Itea virginica*
Celtis laevigata	*Populus heterophylla*
Cephalanthus occidentalis	*Rosa palustris*
Decodon verticillatus	*Salix nigra*
Fraxinus pennsylvanica	*Taxodium distichum*
Fraxinus tomentosa	

Of the 24 swamp trees and shrubs which occur in the study area, 13 of them (roughly 54%) may grow in sites which are completely covered by water throughout the year. The most common of these are the broad-bottomed pumpkin ash, black willow, red maple, and swamp cottonwood. Drummond's red maple and bald cypress are known only from the most remote parts of the swamp. Button-

bush is common throughout the swamp, while water willow, Virginia willow, and swamp rose are local.

When the approximate geographical ranges are plotted for these 13 species, two basic patterns of distribution are evident. In one, the species are centered in the southeastern United States, extending westward usually to Louisiana or eastern Texas, then northward across southern Missouri, southern Illinois, and southwestern Indiana. Then the boundary of the species continues either slightly southward to Virginia and thence along the coast to Florida, or northward through Ohio and into New York and in some cases Connecticut. The southern Illinois stations mark one of the range limits of these species. Such a species may be called extraneous in southern Illinois (following a system of classification developed by Cain, 1930). The other basic pattern is one which includes species whose range is broader and extends usually from northeastern Canada to Manitoba, southward through Minnesota or North Dakota to Kansas or Texas, and finally south-eastward to Florida. For these species, Illinois is more nearly in the center of the range. Such species may be called intraneous in southern Illinois.

Seven of the woody species of the constantly inundated areas fall into the extraneous group. These are Drummond's red maple, southern hackberry, pumpkin ash, water locust, Virginia willow, swamp cottonwood, and bald cypress. On close observation, these are mostly the species which dominate the swamps of the southeastern United States. In southern Illinois, these species are limited usually in their occurrence to our swampy regions. Only the southern hackberry is ever found in considerable numbers in areas which are not continuously inundated.

The intraneous woody species of constantly inundated areas are six in number. They are the red maple, black willow, red ash, swamp rose, water willow, and buttonbush. These range from eastern Canada to Minnesota or North Dakota to Florida and Texas. In southern Illinois, they are more common than the preceding extraneous species. They may be found along streams and in damp woods. Water willow is the only one in the area covered by this study which is confined exclusively to standing water.

Woody Species of Areas Inundated only a Part of Each Year

Acer rubrum	*Itea virginica*
Celtis laevigata	*Populus heterophylla*
Cephalanthus occidentalis	*Rosa palustris*
Fraxinus pennsylvanica	*Salix nigra*
Gleditsia triacanthos	

The nine species which fall into this category comprise 35 and one-half percent of the woody species of the swamp. The majority of them are species which are intraneous and sometimes occur in completely inundated areas. Virginia willow, swamp cottonwood, and southern hackberry are extraneous. The honey locust is the only species in this group which may not also occur in standing water throughout the year. It is intraneous, as one may infer from the variety of habitats in which it is found in southern Illinois.

Woody Species of Low Woodlands Which May Never Grow in Water

Acer negundo	*Gleditsia triacanthos*
Acer rubrum	*Ilex decidua*
Acer saccharinum	*Itea virginica*
Betula nigra	*Liquidambar styraciflua*
Celtis laevigata	*Quercus alba*
Cephalanthus occidentalis	*Quercus palustris*
Cornus obliqua	*Quercus prinus*
Fraxinus pennsylvanica	*Ulmus rubra*

Sixty-six per cent of the woody species encountered in this study (16 out of 24) may grow in areas which are never covered by standing water. Of these, six may occur also in standing water. Virginia willow and southern hackberry are the only ones of these which are extraneous. Elsewhere in southern Illinois the intraneous species may be found in woods bordering streams or in somewhat xeric areas.

Herbaceous Species Which May Be Free Floaters

Azolla mexicana	Naias flexilis
Cabomba caroliniana	Potamogeton diversifolius
Lemna minor	Spirodela polyrhiza
Lemna perpusilla	Wolffia columbiana
Lemna trisulca	Wolffia papulifera
Lemna valdiviana	Wolffiella floridana
Limnobium spongia	

Of the 52 herbaceous species recorded from constantly inundated areas of the swamp, 13 of them (25%) may occur as free floaters. Three of these may also root on occasion—cabomba, pondweed, and naiad. These are found in water which is little if at all stagnated. The other ten species are more common in stagnant waters.

Most of the free floaters are rare in Illinois. *Wolffiella floridana*, *Wolffia papulifera*, *Lemna valdiviana*, *Limnobium spongia*, and *Cabomba caroliniana* are known in Illinois only from one other station in addition to the one in this study area.

In analyzing the distribution of the free floaters, two basic patterns may again be recognized.

Species whose distribution falls under pattern one are the most wide-spread species encountered in the swamp. Their general range is from Newfoundland or Labrador to British Columbia and California and southward usually to Florida and Texas and often into Mexico and tropical America. These are the intraneous species. Those species exhibiting such a wide range include pondweed, naiad, species of duckweed (*Lemna minor*, *L. trisulca*, and *L. valdiviana*), and spirodela. Two variations from this pattern are found. One, exemplified by *Lemna perpusilla*, *Wolffia columbiana*, and cabomba, extends westward only to the plains states, rather than to the Pacific. The range of cabomba is the most narrow, extending from Massachusetts westward to eastern Missouri. The second variation is typified by only one species, the mosquito fern. It is essentially the reverse of the first variation; i.e., it occurs throughout the West, but extends eastward only to Wisconsin. It may be called intraneous, with an affinity to the West.

Only three free floaters of the swamp are extraneous. These are sponge-plant, *Wolffia papulifera*, and *Wolffiella floridana*, predominantly southeastern plants with southern Illinois forming one of their range limits.

All but two of the free floaters are monocotyledons.

Rooted Herbaceous Species Which May Be Found in Constantly Inundated Areas

Acorus calamus	Carex crus-corvi
Alisma plantago-aquatica var. parviflorum	Carex frankii
Alopecurus aequalis	Carex lupuliformis
Asclepias perennis	Carex lupulina
Bidens polylepis	Carex lurida
Brasenia schreberi	Carex retrorsa
Carex comosa	Carex stipata

Ceratophyllum demersum	*Nuphar advena*
Echinodorus cordifolius	*Nymphaea odorata*
Galium tinctorium	*Peltandra virginica*
Glyceria arkansana	*Pontederia cordata*
Glyceria pallida	*Proserpinaca palustris*
Hottonia inflata	*Ranunculus flabellaris*
Iris fulva	*Sagittaria latifolia*
Jussiaea decurrens	*Scirpus validus*
Ludwigia palustris	*Sparganium androcladum*
Lycopus rubellus	*Sparganium eurycarpum*
Nasturtium officinale	*Utricularia gibba*
Nelumbo lutea	*Utricularia vulgaris*
Neobeckia aquatica	

The 39 species in the preceding list, along with the sometimes rooted pondweed, naiad, and cabomba, make this community of plants the richest with respect to the number of species. Twenty-three of these are monocots, with many of them being coarse, robust plants.

In the deepest waters of Wolf Lake are pondweed, naiad, cabomba, and coontail. In water that has a depth of 3 ft may be found yellow water-crowfoot, American featherfoil, water mustard, both species of bladderwort, American water lily, American lotus, fragrant water lily, and watershield. None are common, although the American lotus and American water lily may occur in large patches. In water that is one to two ft deep is the coarse monocotyledonous community. Species of *Carex* abound; arrow-leaf, bur-head, sweet flag, and water plantain are frequent; pickerel-weed and swamp red iris are local; and *Echinodorus cordifolius* and arrow-arum are rare.

Areas covered by only a few inches of water throughout the year occur near the transitional zone, between the swamp and the low woodland communities. It is here that water horehound is most abundant. Other less frequent species are *Ludwigia palustris*, marsh bedstraw (*Galium tinctorium*), *Jussiaea decurrens*, bulrush, sedge (*Carex fankii*), water fox-tail grass (*Alopecurus aequalis*), and two species of manna grass (*Glyceria pallida* and *G. arkansana*).

The distributional patterns for these rooted herbs of constantly inundated areas are more complex than those for the woody swamp species or for the free floaters. A classification for the distributional patterns may be outlined as follows (the number of species in each category in parentheses):

Intraneous (35)	Extraneous (7)
Continental (14)	Southeastern (5)
Eastern U. S. (17)	Northern (2)
Southern U. S. (4)	

Eighty-three percent of these species are intraneous. Continental intraneous species are those whose range is approximately from eastern Canada westward to British Columbia and southward, usually at least to California, Texas, and Florida. Forty-six percent of the free floaters also fall into this group.

Eastern United States intraneous species have smaller ranges than the continental species. They occur from New England or southeastern Canada to Minnesota, south to Texas and Florida. This is the range exhibited by many of the climax species of southern Illinois.

An uncommon pattern is that designated southern United States intraneous, represented by sedges (*Carex cruscorvi* and *C. frankii*), beggar's tick (*Bidens polylepis*), and *Echinodorus cordifolius*. These species are more common south of Illinois, but do extend northward, often into Wisconsin. These seem allied to the more characteristic swamp species, and may represent species which are

better able to survive somewhat drier conditions and are therefore not limited to isolated swampy situations in southern Illinois.

There are only seven species of rooted herbs in constantly inundated areas which are at one of their range limits in southern Illinois. These extraneous species have either an affinity to the southeast or to the north. The southeastern extraneous species are the more truly swamp species; i.e., they are seldom found outside of swampy situations. Included here are swamp red iris, swamp milkweed, American featherfoil, *Jussiaea decurrens*, and manna grass (*Glyceria arkansana*). The latter has an exceedingly limited range, being known only from areas adjacent to the Mississippi River from southern Illinois (where it has one station) to Louisiana.

The northern extraneous species, *Carex retrorsa* and *Alopecurus aequalis*, make up only a small fraction of the natural vegetation of southern Illinois.

Herbs in Partly Inundated Areas, No Canopy

Agrostis palustris	*Lobelia cardinalis*
Asclepias perennis	*Lycopus americanus*
Aster simplex	*Lycopus rubellus*
Aster vimineus	*Mentha spicata*
Cardamine pennsylvanica	*Muhlenbergia frondosa*
Carex vulpinoidea	*Muhlenbergia schreberi*
Commelina diffusa	*Myosurus minimus*
Cyperus erythrorhizos	*Panicum agrostoides*
Cyperus ferruginescens	*Paspalum fluitans*
Cyperus inflexus	*Paspalum geminum*
Epilobium coloratum	*Pluchea camphorata*
Eragrostis hypnoides	*Polygonum hydropiper*
Eupatorium coelestinum	*Polygonum hydropiperoides*
Glyceria striata	*Polygonum sagittatum*
Heliotropium indicum	*Ptilimnium costatum*
Hibiscus lasiocarpus	*Rumex verticillatus*
Ipomoea lacunosa	*Saururus cernuus*
Leersia lenticularis	*Scutellaria lateriflora*
Leersia oryzoides	*Sium suave*
Lindernia dubia	

These 39 species are found in the transition zone between the constantly inundated areas of the swamp and the low woodlands. This area is inundated for a portion of each year. Trees are usually absent in this zone, and the abundance of grasses gives this zone the appearance of a meadow. Over 25 percent of the species in this community are grasses or sedges. Munro grass is common, as is *Carex vulpinoidea*. Lizard's-tail occurs in scattered patches. Plants of water pepper and mild water pepper are found scattered. Some of these species also make their way into the low woodlands. A few are encountered in very shallow water throughout the year.

Eighty-three percent of these species are intraneous. Seventeen species are continental intraneous; eleven are northeastern intraneous; and two are southern intraneous. These last two, mist flower and small white-flowered morning-glory, range from New Jersey through central Illinois to eastern Kansas and south to Florida and Texas.

Six species may be called extraneous. These have affinities to the south and southeast. They include bishop's-weed, marsh fleabane, hibiscus, swamp milkweed, and two species of bead-grass (*Paspalum geminum* and *P. fluitans*).

Herbs of the Low Woodland Community

Apios americana	*Hydrolea affinis*
Asclepias perennis	*Hypericum perforatum*
Aster simplex	*Lycopus americanus*
Aster vimineus	*Lycopus rubellus*
Bidens comosa	*Lysimachia ciliata*
Bidens connata	*Mimulus alatus*
Bidens discoidea	*Ptilimnium costatum*
Bidens vulgata	*Scutellaria lateriflora*
Cardamine pennsylvanica	*Scutellaria nervosa*
Circaea latifolia	*Senecio glabellus*
Galium obtusum	*Sium suave*
Gerardia tenuifolia	*Stachys tenuifolia*
Glyceria septentrionalis	*Triadenum walteri*

The herbaceous members of the low woodland community form a diverse assemblage of species. Some are small and usually rather inconspicuous—*Triadenum walteri*, *Hydrolea affinis*, *Circaea latifolia*, *Scutellaria nervosa*, and *Cardamine pennsylvanica*; others are coarse and vigorous—*Sium suave*, *Asclepias perennis*, and *Ptilimnium costatum*. Large areas of bare ground occur beneath the trees in this community. The herbs that do occur are usually found singly. Occasional patches of manna grass (*Glyceria septentrionalis*) may be found.

Most of these species flower during late summer and fall. Usually only butterweed and enchanter's nighshade can be found in bloom before May 15.

The affinities of these species in general follow those of the other herbaceous communities. Seventy-seven percent of the low woodland herbaceous species are intraneous, half of them being continental intraneous and half northeastern intraneous. Six species (23%) are extraneous with affinities predominantly to the southeastern United States. These are butterweed, pink St. John's-wort (*Triadenum walteri*), bishop's-weed, swamp milkweed, hydrolea, and skullcap (*Scutellaria nervosa*). These extraneous species are confined in Illinois to the swamps of the southern counties; only butterweed is more tolerant in its habitat requirements.

One hundred thirty-three species of ferns and flowering plants have been collected from the study area and deposited in the herbarium of Southern Illinois University. These are distributed among 51 families. Eighty-one species are dicotyledons, 50 are monocotyledons, one is a gymnosperm, and one is a pteridophyte. Cyperaceae is represented by 16 species, Gramineae by 14, Compositae by 11, Lemnaceae by seven, and Labiatae by six species.

Nearly 78 percent of the species recorded from the study area are intraneous (table 1). Of the remaining extraneous species, 93 percent have affinities to the south or southeast.

Species of Other Southern Illinois Swamps

Several swamps are known in southern Illinois, although few have been studied extensively. Many are found in the Cache River bottoms of Johnson and Pulaski Counties. These swamps have a species composition similar to the ones treated in this study although a few species are found in them that have not been recorded from the Wolf Lake area. Conspicuous among these are the water or tupelo gum (*Nyssa aquatica*), water hickory (*Carya aquatica*), willow oak (*Quercus phellos*), storax (*Styrax americana*), planer elm (*Planera aquatica*), and southern buckthorn (*Bumelia lycioides*). Among the herbs may be mentioned *Dulichium arundinaceum*, *Carex louisianica*, *Carex oxylepis*, and *Triadenum tubulosum*.

TABLE 1

Geographical affinities of the species recorded from the swamps

Growth Form and Habitat Type	Number of Species	Geographical Affinities							
		Intraneous					Extraneous		
		Continental	Northeastern	Western	Southern	Total	Southeastern	Northern	Total
Woody; Area Constantly Inundated	13	0	6	0	0	6	7	0	7
Woody; Area Partially Inundated	9	0	6	0	0	6	3	0	3
Woody; Low Woodland Plants	16	0	11	0	0	11	5	0	5
Herbaceous; Free Floaters	13	6	3	1	0	10	3	0	3
Herbaceous; Area Constantly Inundated	42	14	17	0	4	35	5	2	7
Herbaceous; Area Partially Inundated	39	17	14	0	2	33	6	0	6
Herbaceous; Low Woodland Plants	25	11	8	0	0	19	6	0	6
Totals (adjusted so that no species is counted more than once)	133	41	56	1	6	104	27	2	29

SUMMARY

In the northwestern section of Union County, Illinois is a swampy area which is rich in flora and fauna. This area may be divided into three regions: Wolf Lake, Wolf Lake Swamp, and LaRue Swamp. The vegetation may be grouped according to growth form and to the amount of water in which the plants grow. One hundred thirty-three species of ferns and flowering plants have been recorded from the study area. Concerning the woody species, those which grow in constantly inundated areas are for the most part at one of their range limits in southern Illinois. Such species are called extraneous. As the area becomes less swampy, the composition of the woody species becomes increasingly intraneous; i.e., southern Illinois is not one of the geographical boundaries for the species. These species are not confined to swamps in southern Illinois. Herbs are classified into free floaters and rooted floaters. Nearly 78 percent of the total species recorded from the swamp are intraneous. Of the remaining extraneous species, 93 percent have affinities to the south or southeast. Thus, the floristic make-up of the Union County swamp area has a distinct southeastern United States character.

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DAMAGE TO FISH FRY BY CYCLOPOID COPEPODS

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OBSERVATIONS

Some fish fry were obtained from a Lake Erie plankton sample collected at Put-in-Bay, Ohio on July 4, 1958. The fry were examined immediately, but they were dead. Each had from 5 to 7 cyclopoids clinging to it (*Cyclops bicuspidatus* and *Mesocyclops edax*). It could not be ascertained whether the fry had died from the crowded conditions in the sample, or directly from bites by the copepods.

Specimens of the fry of the rockbass (*Ambloplites rupestris*) were obtained. Unfortunately they were well advanced (6.5 mm long), and were more active and alert than younger fry would have been. One of the fish was placed in 10 ml of lake water containing 5 specimens of *Mesocyclops edax*. The copepods had been isolated individually for the previous 24 hr to prevent any feeding. They were between 0.9 and 1.0 mm in length.
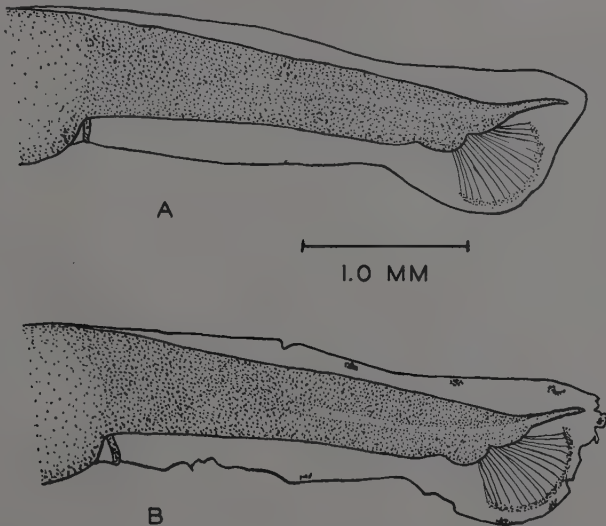
FIGURE 1. Posterior regions of two 6.5 mm fry of the rockbass, *Ambloplites rupestris*. **A.** A control animal, with fins intact. **B.** An animal after being subjected to harrassment by *Mesocyclops edax* for one hour, at a population density equivalent to 500 per liter. The dorsal, caudal and ventral fins are frayed and bruised, with many small and a few larger pieces broken off. Drawings after sketches from life, checked against the same specimens preserved.

There was no indication that copepods swimming nearby were detected by the fish. The copepods, however, paused briefly as they passed near the fish. Thereupon, they suddenly pounced upon it and bit at it. To this stimulus the fish responded rapidly by flicks of the tail that both threw the copepod off and removed the fish from the danger. Often the response of the fish was so rapid that little or no damage was inflicted. However, in the course of half an hour, damage to the caudal and ventral fins became evident (bites on the head and other

parts of the body left no evidence visible with the lighting conditions used). The damage to the fins consisted mainly of a gradual fraying of the edges, the loss of small pieces, and the appearance of bruised spots. However, one copepod succeeded in removing a piece of the ventral fin nearly its own size, and some others removed rather sizable portions. After about an hour of harrassment, the fry showed distinct signs of fatigue.

Figure 1 shows the damaged fins of the experimental fish, compared to sound ones from a control fish.

DISCUSSION

It is well known that fresh-water cyclopoids form an important part of the food of many fish. It is evident, however, that a certain amount of harm may be done by them to the relatively helpless fry. Most such juvenile fish, in fresh waters, lie on the bottom, somewhat protected from predation by planktonic copepods. On the other hand, many cyclopoids regularly explore the benthic region for food. In the conditions of the described experiment the concentration of *Mesocyclops* was equivalent to 500 per liter, a quantity that is not infrequently encountered in nature. The actual and potential damage inflicted by cyclopoids upon fish fry needs to be assessed more precisely by larger-scale experiments, and by observations in the field.

It has been shown that some fresh-water cyclopoids are herbivorous while others are predatory (Fryer, 1957a, 1957b; Naumann, 1923). Practically all reports of predation by them concern only their capture of smaller prey, such as nauplii, adult copepods, rotifers, mosquito larvae, etc. Oliva and Sládeček (1950), however, reported the death of axolotl young (about 2 cm long) "attacked by . . . numerous *Cyclops*," and they mentioned a similar observation earlier by Babák (1913). A search of the literature failed to disclose other reports.

Many aquarium hobbyists are highly suspicious of *Cyclops*, but they are sharply divided in their views respecting the danger (e.g., see Ghadially, 1957 and Innes, 1955). Some advocate using cyclopoids as fish food, whereas others fear that breeding is poor in the presence of these copepods. Undoubtedly the different viewpoints are the result of experiences with different species of Cyclopidae, some vegetarian and some predatory, from which broad generalizations incriminating or exonerating all species have been made. The present observations support the contention that at least some cyclopoids may be harmful to the young of aquarium fish.

ACKNOWLEDGMENTS

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LEVELS OF ASPIRATION AND FAMILY AFFECTION: RELIGIOUS PREFERENCE AS A VARIABLE*

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Upward social mobility has been the focus of both theoretical and empirical investigations in many disciplines. While American society emphasizes upward mobility as a cultural goal, individuals exhibit widely different levels of aspiration. Some persons show a greater desire to achieve the rewards of upward social mobility while others seem more content with lower expectations. Two viewpoints suggest possible factors which may account for these differential levels of aspiration.

One point of view focuses on interpersonal variables and their relationship to differential aspiration. This approach is illustrated by the psychoanalytic theory which suggests that certain types of interpersonal relations in early childhood produce insecurity which is later translated into striving for power, recognition, and success. Horney and Adler, among others, have emphasized this theoretical conception (Horney, 1937). In a previous paper, evidence was presented indicating that unsatisfactory interpersonal relationships in the family of orientation were significantly related to high levels of occupational aspiration while satisfactory relationships were related to low aspirational levels (Dynes, Clarke, Dinitz, 1956). It was suggested at that time, however, that the interpersonal interpretation of striving might be a more acceptable explanation for some segments of the population than for others.

A second viewpoint minimizes these interpersonal variables and emphasizes the fact that aspirational levels are frequently a function of the person's position in the social structure (Empey, 1956). Thus, when considering levels of aspiration in differing subcultural groups, modifications may be necessary in this interpersonal explanation. For example, are there segments of the population in which affectional relationships are not directly related to aspirations? In an attempt to provide evidence bearing on this question, this paper is concerned with the association between aspirational level and family affectional relationships in two different population groups representing somewhat different subcultures, i.e., Protestants and non-Protestants. As a result of this analysis of aspirational levels, certain questions were raised concerning the nature of affectional relationships within the two population groups. These differences seemed to be explained by differing family structure. This paper, therefore, is also concerned with the association between affectional relationships and differing family types as they seem to be represented by Protestants and non-Protestants.

THE STUDY DESIGN

The research design required a measure of aspirational level, an indication of religious preference, and certain measures of satisfaction with interpersonal relationships within the family of orientation. While aspirations have been measured in many ways, it was felt, for the purpose of this study, an occupational referent represented the most adequate single measure. The scale selected was developed by Reissman and was concerned with the willingness of individuals to forego certain satisfactions in order to achieve occupational advancement (Reissman, 1953). In this scale, eleven considerations were specified that might prevent a

person from advancing in rank and salary in their occupation. Among these considerations were: leaving one's family for some time, endangering one's health, moving about the country, keeping quiet about political views, etc. Each consideration was evaluated in terms of three alternatives (1) whether it might stop the individual from making a change; (2) whether it might be a serious con∸ sideration but would not stop them; (3) whether it wouldn't matter at all. Only the first alternative was scored. The reasoning behind the scoring was based on the inference that persons permitting the considerations to stop them from making a change were expressing lower levels of aspiration than those disregarding these factors in order to attain higher occupational status. Since the scale had previously been used simply to differentiate gross categories rather than individual differences, the sample was divided into "high" and "low" aspirers, similar to the division employed by Reissman. Operationally, respondents who received scores from zero to 19 were defined as "high" aspirers and those who scored 20 or more comprised the "low" aspirers.

Data were also obtained on the affectional patterns in the family of orientation. The respondent's relationship with his parents was the major concern. Among the areas investigated were: amount of conflict, degree of attachment, feelings of rejection, parental favoritism and fear of punishment from parents. It should be noted that each dimension focused on the respondent's definition of his relationship. Even if the definitions were not objectively true to others, they were, of course, subjectively true to the respondent. The concern was with the respondent's definition of the situation.

Religious preference was indicated by each respondent. Approximately two-thirds of the individuals specified Protestant affiliations. The non-Protestant category included: Jews, 43.3 percent; Catholics, 38.3 percent; other (predominately Greek Orthodox), 18.3 percent. These respondents were combined for the purposes of this study since a comparison of affectional relationships among Catholics, Jews, and other non-Protestants indicated no significant differences. Although this combination might obscure differences for certain purposes, in this instance it was felt that they could justifiably be combined.

The scale measuring aspiration levels and the indices of family affection were administered in questionnaire form to 350 university students enrolled in introductory and advanced social science classes. All questionnaires were answered anonymously. This analysis is confined to the 151 male respondents. Female respondents were not included here because of insufficient numbers in certain categories. Where analysis of the female respondents was possible, however, the results tended to parallel the findings of the male sample.

THE FINDINGS

Aspirational Level and Family Affectional Relationships

In analyzing the association between aspirational level and family affectional relationships, the sample was first divided into Protestants and non-Protestants and, within these categories, differences in the affectional relationships between high and low aspirers were analyzed. In other words, within each group, high and low aspirers were compared in regard to their early affectional relationships.

The results of these classifications tended to support the psychoanalytic theory *for the Protestant segment of the sample*. Protestants with high aspirations generally showed poorer affectional relationships in the family of orientation than did those with low aspirations. Specifically, a significantly greater proportion of the high aspirers rated their own childhhoods as "unhappy," perceived that both their parents had defined a favorite child within the family, confided rarely in their fathers, were fearful of punishment from their mothers, and more frequently had felt unwanted by both of their parents. These findings are summarized in table 1, columns one and two.

Contrary to the analytic theory, however, no significant differences were found between non-Protestant high and low aspirers in reference to their early affectional relationships. Affection, or the lack of it, was not related to levels of aspiration among the non-Protestants (table 1, columns three and four).

A second classification compared Protestants and non-Protestants *within* the high aspiration category and then compared these groups within the lower aspiration category. In other words, the high aspirers in both groups were compared in terms of their affectional relationships. The low aspirers were compared in the same manner.

In this analysis, it was found that the two groups did not differ significantly on affectional variables at the high aspiration level. (An exception to this finding occurred between Protestant and non-Protestant high aspirers who "felt unwanted by mother" [P < .05].) (Compare columns one and three, table 1.) In general, *high* aspirers, both Protestant and non-Protestant, might be characterized as having experienced generally poorer affectional relationships.

TABLE 1

Affectional relationships of Protestant and non-Protestant males in relation to levels of aspiration, in percentages

Ratings of affectional relationships	Protestant Aspiration level			Non-Protestant Aspiration level		
	High (N=38) (1)	Low (N=53) (2)	P*	High (N=22) (3)	Low (N=38) (4)	P†
"Unhappy" childhood	31.6	.7.7	.02	47.4	36.8	—
Favoritism shown by father	44.4	17.5	.02	46.7	53.1	—
Favoritism shown by mother	40.7	12.5	.01	40.0	40.6	—
Rarely confided in father	52.8	30.8	.05	· 57.1	54.1	—
Feared punishment by mother	57.9	36.5	.05	36.4	34.2	—
Felt unwanted by father	41.7	17.3	.02	50.0	45.9	—
Felt unwanted by mother	26.3	5.8	.01	45.5	32.4	—

*Probability of obtaining a Chi-square as great or greater by chance.
†Each Chi-square in this column is below the .05 level of significance.

At the *low* aspiration level, however, the data revealed a pattern of significant differences. In contrast to the non-Protestants, the Protestant *low* aspirers indicated more satisfactory relationships (Compare columns two and four, table 1). For example, they rated their childhoods as generally happy (P < .01), confided more often in their fathers (P < .05) and perceived their fathers as showing less favoritism toward children in their family (P < .05). In addition, they experienced fewer feelings of being unwanted by either their father (P < .02) or their mother (P < .01).

The evidence presented thus far can be summarized briefly at this point. *High aspirational level for the Protestants was significantly related to unsatisfactory affectional relationships and low aspirational level was related to satisfactory relationships. For the non-Protestants, however, affection was less directly related to aspiration as both high and low aspirers reported relatively less satisfactory affectional relationships.*

Interpreting these results, it would appear that while poor affectional relationships may be associated with high aspirations in the Protestant group, other factors probably operate in similar manner for the non-Protestants. For example, it has frequently been observed that a "success" orientation is characteristic of at least some segments of the Jewish subculture and that education often serves as a

vehicle for achieving higher status.   It may be that what is called the Protestant ethic is no longer peculiarly Protestant, if ever it was.   One could argue that the Protestant ethic in the United States is in many respects a minority group ethic.

Given these subcultural values, centered on achievement, poor affectional relationships would appear to add little to the explanation of high aspirational levels in this instance.   Consequently, in order to explain more adequately differing or even similar levels of aspiration within and among some groups, it may be necessary to give greater consideration to such factors as minority group status, ethnic origin and family structure, rather than focusing primarily on early interpersonal relationships.   The same level of aspiration may be explained by differing means—cultural as well as interpersonal.

Affectional Relationships and Differing Family Types

The preceding analysis has attempted to indicate and interpret differences in the degree of satisfaction with early family affectional relationships between (1) high and low aspirers within Protestant and non-Protestant groups, and between (2) Protestants and non-Protestants at similar levels of aspiration.   Since neither the mean aspirational level nor the social background characteristics of the Protestant and non-Protestant groups in the sample varied significantly, these groups were again compared, this time *disregarding aspirational level as a factor*. As may be seen in table 2, this analysis supported the previous conclusion that non-Protestants in general, had experienced less satisfactory affectional relationships.

TABLE 2

Affectional relationships of Portestant and Non-Protestant males, in percentages

Ratings of affectional relationships	Protestant ($N=91$)	Non-Protestant ($N=60$)	P*
"Unhappy" childhood	17.6	39.7	.01
Rarely confided in mother	24.2	38.7	.02
Conflict with mother	17.0	40.0	.01
Felt unwanted by father	27.0	47.5	.02
Felt unwanted by mother	15.4	37.3	.01

*Probability of obtaining a Chi-square as great or greater by chance.

At this point the question arises as to why the non-Protestants reported less satisfaction with their early family affectional relationships.   One possible explanation would seem to be found in the types of family structure which these two groups may be presumed to have experienced.   It is probable that the non-Protestants are to a greater extent products of the "traditional" family.   This type of family is characterized by greater paternal authority, strong family ties, and emphasis on the role obligations of family members.   Individuals fulfilling these rigid role obligations may conceive of their relationships within the family of orientation as being overly restrictive, hence, unsatisfactory.   When new standards for evaluating family experiences are presented in a more permissive social atmosphere (e.g., a college campus), and prior to the formation of one's own family of procreation, these relationships may appear in retrospect to have been less satisfactory.

On the other hand, the family structure of Protestants is usually assumed to

correspond more closely to the "companionship" type, emphasizing personal independence, absence of the more rigid types of control, and companionship in interpersonal relations. As a consequence, members of this type of family may consider their relationships, or at least look back on them, as having been more personally satisfying.

If the inference is correct concerning differences in the nature of the family type of Protestants and non-Protestants, this would seem to imply that satisfactory interpersonal relationships *are not* necessarily the by-product of the cohesiveness of the "traditional" family. This would contradict a conventional view in the sociology of the family literature and the public image which interprets individual happiness as a function of this cohesiveness. It may well be that as affection becomes increasingly separated from the fulfillment of role obligations, as it does in the "companionship" family, relationships between parents and children, and, perhaps, between husband and wife, become more personally satisfying. Empirical evidence bearing on some aspects of this issue is to be found in Landis and Stone (1952).

SUMMARY

It was found, in support of the psychoanalytic theory, that in a Protestant population high levels of occupational aspiration were significantly associated with unsatisfactory family affectional relationships and low aspirational levels were related to satisfactory affectional relationships. Affection, or the lack of it, was not related to levels of aspiration among a comparable sample of non-Protestants. It was suggested, therefore, that the etiology of high aspirational levels among persons in this category may have to be explained primarily in terms of subcultural factors rather than purely interpersonal variables.

It was also found that regardless of aspirational level, the early affectional relationships of the Protestants were generally more satisfactory than those of the non-Protestants. Differences in family structure were posited as a plausible explanation for this latter finding. However, as subculture differences in family structure diminish and families more closely approximate the "companionship" type, it may well be that all groups will more directly channel unsatisfactory interpersonal relations into high levels of occupational aspiration. In this event, perhaps disciplinary differences between the sociologist and psychoanalyst will become less important and a more unified view of the etiology of aspirations may emerge.

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THE CRAYFISHES OF NEW JERSEY[1]

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The only study of the crayfishes of New Jersey was by Henry W. Fowler (1912) in the Annual Report of the New Jersey State Museum for 1911. Fowler's subject was the crustacea of the state and was too broad for a comprehensive treatment of the crayfishes. Little or no information is given on the distribution, life histories or ecology of the New Jersey species. The crayfishes of the adjacent states have been extensively studied by Ortmann (1906) in Pennsylvania and Crocker (1957) in New York. The Present study has the following aims: to identify and determine the distribution of the New Jersey crayfishes, to study the life histories and ecology of the species encountered, and to compare the morphology of the New Jersey crayfishes with those of adjacent regions and to investigate relationships, pathways of dispersion and barriers to migration.

METHODS AND MATERIALS

During the spring and summer of 1957, the author collected in 151 stations which covered 19 of the 21 counties of New Jersey. More Stations were established in counties in which crayfish were scarce than in those where crayfish were found to be abundant. Fifty-one of the 150 locations yielded at least one specimen.

Collection data from the American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, the United States National Museum, the Museum of Comparative Zoology, and Mr. Roland Smith, Principal Fisheries Biologist of New Jersey were examined by the author. Collection data and two live *Cambarus diogenes* were received from Mr. J. Albert Starkey of Vineland, New Jersey. The collections of the Academy of Natural Sciences of Philadelphia and the American Museum of Natural History were examined and a specimen of *Cambarus diogenes* was obtained on loan from the United States National Museum. Together with published records of New Jersey crayfishes, the data herein contained represent records from 138 stations (some of which are duplicates) in every county of the state except Hudson.

Collecting was done by the author with common seine, dip net, and by hand. All specimens were preserved in 80 percent ethyl alcohol. Hydrogen-ion concentration of all waters was determined with Lamott colormetric pH indicators.

The drawings (fig. 1, 3, 5, and 7) of the chelae and carapaces are based on actual measurements of the crayfish made with dividers and transferred to the paper. Those of the seminal receptacles and gonopods are camera lucida drawings. Obvious pubescence has been indicated, but no indication of this on the drawing does not necessarily indicate a lack of pubescence on the specimen. The curvature of the various parts has been indicated by stippling. A solid line indicates an actual structure on the animal.

The following abbreviations will be used where applicable throughout this paper:

AMNH—American Museum of Natural History
ANSP —Academy of Natural Sciences of Philadelphia
MCZ —Museum of Comparative Zoology
NYSM —New York State Museum
USNM —United States National Museum
DDF   Donald D. Francois

Systematic List of New Jersey Crayfishes

Procambarus Ortmann, (1905b: 437).
  Blandingi Section (Ortmann, 1905a: 98).
    Blandingi Group (Ortmann, 1905a: 102).
      Blandingi Subgroup (Hobbs, 1942b: 93).
        Procambarus blandingi blandingi (Harlan), 1830.
Orconectes Cope, (1872: 419).
  Limosus Section (Ortmann, 1905a: 108).
    Orconectes limosus (Rafinesque), 1817.
Cambarus Erichson, (1846: 88).
  Bartoni Section (Ortmann, 1905a: 119).
      Cambarus bartoni bartoni (Fabricius), 1798.
  Diogenes Section (Ortmann, 1905a: 119).
      Cambarus diogenes Girard, 1852.

Key to the Known Crayfishes of New Jersey

A.` Rostrum without lateral spines; margins subparallel, forming rounded shoulders as they converge into a terminal blunt spine.
  B. Areolae narrowly linear or obliterated.... *Cambarus diogenes* (fig. 7).
  BB. Areolae broad and short............ *Cambarus bartoni bartoni* (fig. 5).
AA. Rostrum with lateral spines and without rounded shoulders.
  B. Rostrum large with broad base, margins uniformly converging to an acute tip; small lateral spines located very close to tip............
              Procambarus blandingi blandingi (fig. 1).
  BB. Rostrum deeply concave with margins nearly parallel; lateral spines large and conspicuous.................. *Orconectes limosus* (fig. 3).

Hydrogen-Ion Concentration

An ecological factor which varies considerably in the open water of the State of New Jersey is the hydrogen-ion concentration or pH. This ranges from a pH of 3.8 in some of the "cedar waters" of the Atlantic coastal plain in the southeast to 9.5 in the glaciated piedmont plateau of northern New Jersey. In the collections made by the author the following ranges of pH were observed for the crayfishes found in the state:

Procambarus blandingi blandingi........................ 3.8 to 8.5
Orconectes limosus....................................... 6.4 to 9.4
Cambarus bartoni bartoni............................... 7.6 to 8.5
Cambarus diogenes...................................... no data

The significance of low or high pH upon crayfish is difficult to determine, but certain observations have been made. In the acid waters of the state the most striking and frustrating feature is the scarcity of crayfish. The author has collected extensively in acid waters were reliable zoologists had reported crayfish, but failed to take one. Crayfish of the acid waters have much thinner exoskeletons than do individuals of the same species from more alkaline waters. This was observed even in some large form I males. This may be due to the low calcium content of the water.

Mr. Roland Smith, Principal Fisheries Biologist of New Jersey, reports (personal communication) that crayfish in the acid waters of the state are a preferred food of the Eastern Chain Pickerel. This is not clearly understood, but perhaps it is associated with the fact that the crayfish of these waters have very thin shells.

Whether pH is a limiting factor in the distribution of crayfish is uncertain. The lack of typical *Cambarus bartoni bartoni* habitat in the Atlantic coastal plain

undoubtedly has restricted this species to northern New Jersey. The normal habitat of *Orconectes limosus*, however, differs from that of the Atlantic coastal plain only in pH. Hence the acidity of the water probably has played a major role in keeping *O. limosus* out of the Atlantic coastal plain.

Procambarus blandingi blandingi (Harlan)

Figures 1 and 2

Astacus blandingi Harlan, 1830: 464–465.
Astacus (Cambarus) blandingi Erickson, 1846: 98–99.
Cambarus blandingi Hagen, 1870: 43–45.
Cambarus acutus Abbott, 1873: 80–84.
Cambarus (Cambarus) blandingi Ortmann, 1905a: 96–97.
Cambarus (Ortmannicus) blandingi Fowler, 1912: 340–341.
Cambarus blandingi acutus Faxon, 1914: 367.
Procambarus blandingi blandingi Hobbs, 1942a: 341–342.

Type locality.—"Marshes and rivulets, Southern United States [Camden, Kershaw Co., S. C.?]" Faxon (1914: 413).

Taxonomic remarks.—Crocker (1957: 30) gives a complete description of a form I male and a female from the Bronx River in Westchester County, New York. The *P. b. blandingi* examined from New Jersey agree with Crocker's description in most respects. There are, however, certain differences which were observed in the New Jersey specimens. Crocker describes the carapace as covered with tubercules and granular to the touch. In the New Jersey specimens these tubercules are often so reduced that the carapace feels smooth. The areolae of all New Jersey specimens examined have at least two and often three rows of punctations at the narrowest point (fig. 1.1) in contrast to the one row of punctations at the narrowest point described by Crocker.

The chelae of the New Jersey *P. b. blandingi* (fig. 1.2) show great variation. They are generally small and weakly developed and in some of the smaller specimens but slightly larger than the second pair of walking legs. In the larger and presumably older specimens the chelae are longer, stouter, and generally better developed. The number of tubercules and their arrangement on the inner edges of the fingers of the New Jersey specimens vary with no apparent trend in their frequency or location. In older specimens it is possible to separate the sexes by the size and shape of the chelae alone. The females have shorter, stouter chelae while the males have chelae that are longer and narrower. The notch at the base of the movable fingers of females and the bladelike setae on the inner surface of the fingers of males described by Crocker is evident only in some New Jersey specimens. This appears to be associated with aging, but not enough material is available to diagnose these variable characters accurately. The seminal receptacles (fig. 1.4) of the females examined exhibited a variety of shapes and seem to be of little taxonomic value.

Habits.—*Procambarus blandingi blandingi* usually are found associated with aquatic vegetation. They are found, however, in bodies of water that have very little vegetation as Stephens Creek at Estellville in Atlantic County. In this creek a form I male was collected from under a log on a gravel bottom. In Maryland this species is reported to make burrows and inhabit the salt marshes which are covered twice daily by the tides (Faxon, 1885b: 23). No crayfish were found inhabiting the salt marshes of New Jersey. This species also is reported to occur in polluted water in association with decaying vegetation and deep muck (Crocker, 1957: 69).

EXPLANATION OF FIGURES

FIGURE 1. *Procambarus blandingi blandingi*. **1**. Carapace. Male. carapace length 40 mm. Stephens Creek at Route 50, Estellville. Atlantic County. September 24, 1957. DDF 63. **2**. Right chela. Same specimen as number 1. **3**. Lateral aspect of right form I gonopod. Same specimen as number 1. **4**. Seminal receptacle. Female. carapace length 37 mm. Greenwood Lake, Hewett. Passaic County. March 15, 1957. DDF 9. **5**. Lateral aspect of right form II gonopod. Male. carapace length 30 mm. Oyster Creek at Route 9. Waretown, Ocean County. June 21, 1957. DDF 44.
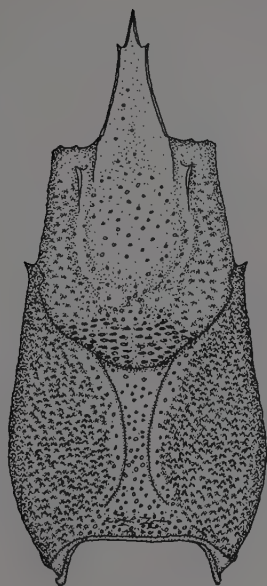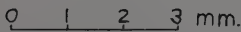
In New Jersey this species is found in small creeks, large sluggish rivers, and lakes. These bodies of water exhibit a great diversity of ecological conditions. Some of the streams in which *P. b. blandingi* are found are crystal clear, cold, and have a high hydrogen-ion concentration (pH 3.8) while others are muddy, warm, and alkaline (pH 8.5). The lakes in which they are found also vary in nature. This species has a great range of tolerence of such variable factors as pH, pollution, temperature, vegetation, turbidity, and bottom composition.

Life history.—Little information is available. There are no records of females with eggs or young and no observations of copulation. Crocker (1957: 68) reports a female with a sperm plug collected in August. The author has collected females in March with sperm plugs. Form I males have been collected in June, July, August, and September. On the basis of this fragmentary evidence, mating probably occurs in the late summer and fall and spawning in the spring.

Distribution.—This species inhabits most or all of the Atlantic coastal plain and has been collected as far north as Greenwood Lake in New York State (fig. 2). Greenwood Lake lies half in New York and half in New Jersey in mountainous country deep in the glaciated area. Crocker (1957: 71) states, "*P. b. blandingi* . . . has not left its lowland habitat." This is in error, but to what extent it has invaded the glaciated area is uncertain. This species possibly extends much farther into New York State than we are aware. *Procambarus blandingi blandingi* is able to exist in small, inconspicuous populations that easily escape detection. In some lakes extensive collecting yielded no crayfish yet a pickerel from the same water contained a specimen of this species.

Ortmann (1905a: 103–106) places the origin of the genus *Procambarus* in Mexico and the center of the Blandingi Section in Alabama and Georgia. He postulates that it entered Florida and spread northeastward along the Atlantic coastal plain. All available evidence supports this theory.

New Jersey Records of Procambarus blandingi blandingi

Atlantic County

Nacote Lake (from stomach of pickerel), Port Republic, Aug. 29, 1957. DDF 58.
Stephens Creek at Route 50, Estellville, Sept. 24, 1957. DDF 63.
Batso Pond (Batso River), Batso. J. A. Starkey. Personal communication.
Branch of Little Egg Harbor River, Folsom. J. A. Starkey. Personal communication.

Burlington County

Medford Lakes, June 5, 1903. S. N. Rhoads. ANSP 1570.
Chatsworth Lake, Chatsworth, Sept. 15, 1957. DDF 59.

Cumberland County

Vineland, 1950. J. A. Starkey. USNM 91425.
Little Robin Branch of Maurice River, Vineland. J. A. Starkey. Personal communication.
Maurice River at Almond Road Bridge. J. A. Starkey. Personal communication.

Essex County

Essex County. Faxon (1885b: 19).

Gloucester County

Repauto Creek, Repauto, April 19, 1908. B. N. Griffiths and H. W. Fowler. ANSP 4828.
Mantua Creek, Mantua, April 8, 1906. H. W. Fowler and S. H. Hamilton. ANSP 5647 and 4826.
Racoon Creek at Route 45, Mullica Hill, Sept. 15, 1957. DDF 60.
Branch of Upper Egg Harbor River, Downstown. J. A. Starkey. Personal communication.

Mercer County

Tributary of Crosswicks Creek, Trenton, July 13, 1901. H. W. Fowler, T. D. Keim, and C. B. Abbott. ANSP 4827.

Millpond at Grover's Mills, Princeton Junction.　Ortmann (1905a: 131).
Delaware-Raritan Canal, aqueduct near Princeton.　Ortmann (1905a: 131).
Trenton.　Abbott (1873: 80).
Delaware River and tributaries, Trenton.　Faxon (1885b: 19).

Middlesex County

Farrington Lake at Route 130, South Brunswick, March 18, 1957.　DDF 17.
Millpond, Plainsboro.　Ortmann (1905a: 131).

Ocean County

Mill Creek at Route 9, Manahawken, June 21, 1957.　DDF 43.
Oyster Creek at Route 9, Waretown, June 21, 1957.　DDF 44.
Oyster Creek, 1953.　R. Smith.　Personal communication.

Passaic County

Greenwood Lake, Hewett, March 15, 1957.　DDF 9.

FIGURE 2.　Stream map of New Jersey showing locations of collections of *Procambarus blandingi blandingi*.

Salem County

Allowaystown, Sept. 7, 1901.　H. W. Fowler, and S. N. Rhoads.　ANSP 5296.
Branch of Muddy Brook near Palatine Lake, 1949.　J. A. Starkey.　USNM 92917.
Muddy Run Brook at Jesse's Bridge, Norma.　J. A. Starkey.　Personal communication.
Muddy Run Brook, Elmer.　J. A. Starkey.　Personal communication.
　　Localities from which crayfish, which are presumed to be *Procambarus blandingi blandingi*, have been taken:
Hammonton Lake, Hammonton, Atlantic County.　R. Smith.　Personal communication.

Absegami Lake, Bass River State Forest, Burlington County. R. Smith. Personal
    communication.
Manasquam River, Monmouth County. R. Smith. Personal communication.
Deer Head Lake, Toms River, Ocean County. R. Smith. Personal communication.
Upper Takanassee Lake, Ocean County. R. Smith. Personal communication.
Upper section of Maurice River, Salem County. R. Smith. Personal communication.

Orconectes limosus (Rafinesque)

Figures 3 and 4

Astacus limosus Rafinesque, November 1817: 42.

Astacus affinis Say, December 1817: 168.

Astacus bartoni Milne-Edwards, 1837: 331.

Astacus (Cambarus) affinis Erichson, 1846: 96.

Cambarus affinis Girard, 1852: 87.

Cambarus pealei Girard, 1852: 87.

Cambarus (Faxonius) limosus Ortmann, 1905a: 107.

Orconectes limosus Hobbs, 1942a: 352.

Type locality.—". . . muddy banks of the Delaware, near Philadelphia." Rafinesque,
1817: 42.

Taxonomic remarks.—*Orconectes limosus* examined from New Jersey agree with the excellent
diagnoses of Ortmann (1906: 352–356) and Fowler (1912: 354–356). The specimens of *O. limosus*
examined by Ortmann included 54 from New Jersey.

Habits.—Fowler (1912: 357) characterizes *O. limosus*: "The river crayfish does not make
much, if any, of a burrow, but usually hides under stones or in aquatic vegetation. It also
does not live in rough rocky streams, but inhabits quiet or tidal fresh waters. . . ." With a
few exceptions, this description is acceptable. The author has often taken *O. limosus* in quite
swift water and from a rocky bottom. In primrose Brook, a tiny stream near Morristown,
this species was collected along with *Cambarus bartoni bartoni* from beneath the rocks of a small
rock dam. If there are rocks or rubble present in a stream, this probably is the best place in
which to look for *O. limosus*, but stands of aquatic vegetation also should be examined.

Most authorities agree that *O. limosus* is not a burrowing crayfish. In Van Saun Brook,
Riveredge, the author has observed and collected it in burrows. The burrows were made in a
clay bank under water. They were 9 to 16 in. deep with very few branches or side tunnels.
The observations and collection were made in March and include one copulating pair. This
pair will be discussed in more detail under the life history of this species.

Life history.—Ortmann (1906: 478) summarizes the life history of *O. limosus* by noting,
"The mating season in the fall, the spawning season in spring, and the absence of males of the
first form in early summer (June and part of July). . . ." Ortmann takes exception the work
of Andrews (1904: 166) who states that the normal mating season is in the months of February,
March, and early April. Andrews also is of the opinion that there is an autumnal pairing in
October or November ". . . in place of or in addition to the spring pairing." Ortmann feels that
Andrews' observations, which were made in the laboratory, lead to an error, the warm water in
the laboratory in March causing the crayfish to copulate unseasonably.

The author's observations of *O. limosus* copulating in March tend to endorse Andrews'
work. The copulating pair was captured by reaching into a burrow and grasping the two cray-
fish. When withdrawn from the burrow, the crayfish were in a copulating position; however,

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EXPLANATION OF FIGURES

FIGURE 3. *Orconectes limosus.* **1.** Carapace. Male, carapace length 36 mm. Van
Saun Brook, Riveredge, Bergen County, August 21, 1957. DDF 45. **2.** Right chela. Same
specimen as number 2. **3.** Lateral aspect of right form I gonopod. Same specimen as num-
ber 1. **4.** Seminal receptacle. Female, carapace length 37 mm. Van Saun Brook, River-
edge, Bergen County, August 21, 1957. DDF 45. **5.** Lateral aspect of right form II gonopod.
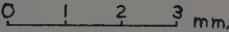Male, carapace length 33 mm. Greenwood Lake, Hewett, Passaic County, June 8, 1957.
DDF 33.
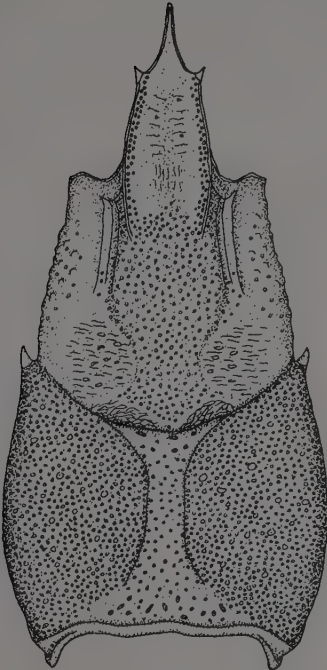
they separated before they could be examined closely. This female was the only one in this collection. The other eight crayfish taken were first form males. Some of the males were collected in burrows and others in depressions in the stream bed where they were seen easily and caught.

This same stream was revisited on August 21, 1957, and a large number of copulating *O. limosus* was found. They were not easily disturbed and could be handled and taken out of the water without separating. The position and maneuvers of the males in copulation and approach to copulation were identical with Andrews' observations.

The author is of the opinion that mating of *O. limosus* usually occurs in the late summer and fall. Perhaps there is a supplemental spring mating season or perhaps they may copulate irregularly through the winter. The bulk of evidence available, however, indicates a fall mating season. More information is needed before the significance of this March copulation record is fully understood.

The smallest form I male *O. limosus* (ANSP 5320) examined had a carapace 19 mm long and was collected by E. S. and W. L. Mattern from Schwartzwood Lake outlet on October 21, 1917. A female of this species (NYSM 7000) with a carapace 22.5 mm long and with a sperm plug was collected by D. W. Crocker (1957: 56). These are the smallest sexually mature *O. limosus* recorded.

Ortmann (1906: 479) found a female with eggs on May 9 and a female with young on May 30. The author collected a female with young from Greenwood Lake on June 8.

Ortmann (1906: 479) observed copulation of this species in January and again on November 4 in the laboratory, but only on September 4 and 10 in the field. The author has observed copulation of this species on March 14 and August 21.

Distribution. –Undisputed records of *O. limosus* are from the states of Pennsylvania, Virginia, District of Columbia, Maryland, New Jersey and New York (Crocker, 1957: 78). In New Jersey this species is found in the Delaware River drainage, extending into the Atlantic coastal plain and in glaciated northern New Jersey (fig. 4). The one exception to this is Faxon's (1885b: 86) record for Red Bank, presumably from the Navesink River. The headwaters of the Navesink and the headwaters of a branch of the Raritan River are only a few miles apart in the lowlands north of Freehold. They no doubt have been connected at one time and the southern migration of *O. limosus* effected by this connection.

The crayfishes with the closest affinities to *O. limosus* are found in the Mississippi drainage in Kentucky, Missouri, and Indiana. The origin of the Limosus Section of *Orconectes* is in the central part of the Mississippi drainage. The present morphological and geographical isolation of *O. limosus* indicates the antiquity of the Limosus Section (Ortmann, 1906: 428–432). Ortmann further states, "*Cambarus limosus* is a Tertiary type and it reached its present area coming from the west and by way of the north, being driven south along the Atlantic Coastal Plain by the advancing ice of the Glacial Period." When Ortmann wrote this he was not aware of the present range of *O. limosus* into New York state or even that it positively existed north of New Jersey. With the knowledge of the distribution of this species in New York now available (Crocker, 1957), there is little doubt that it reached its present distribution by the route outlined by Ortmann.

New Jersey Records of Orconectes limosus

Bergen County

Van Saun Brook, Riveredge, March 14, 1957. DDF 3.
Saddle River at Route 4, Ridgewood, March 15, 1957. DDF 4.
Ramapo River at Glen Gray Bridge, Oakland, March 15, 1957. DDF 7.
Van Saun Brook, Riveredge, August 21, 1957. DDF 45.

Burlington County

Medford Mills, June 5, 1903. S. N. Rhoads. ANSP 5611.
North Creek, Burlington, May 29, 1910. H. W. Fowler and T. D. Keim. ANSP 5083.
Delaware River, Bordentown, August 29, 1909. C. C. Abbott, T. D. Keim, and H. W. Fowler. ANSP 5084.

Florence Creek, Florence, May 15, 1910.   H. W. Fowler.   ANSP 5171.
Below Burlington, June 17, 1910.   H. W. Fowler.   ANSP 5170.
Blacks Creek at Route 206, Bordentown, August 23, 1957.   DDF 56.
North Branch of Rancocas Creek at Route 206, Mount Holly, August 23, 1957.   DDF 57.
Burlington Islands.   Fowler (1912: 357).
Burlington.   Faxon (1885b: 86).
Burlington Islands, April 16, 1884.   C. C. Abbott.   MCZ 3688.

Camden County

Coopers Creek, Camden, Oct. 29, 1916.   J. Aebley.   ANSP 5610.
Camden, E. Dittenbaugh.   ANSP 409.
Delaware River, North Cramer Hill, Sept. 1904.   Ortmann (1905a: 131).
Delaware River, Camden.   Ortmann (1906: 357).
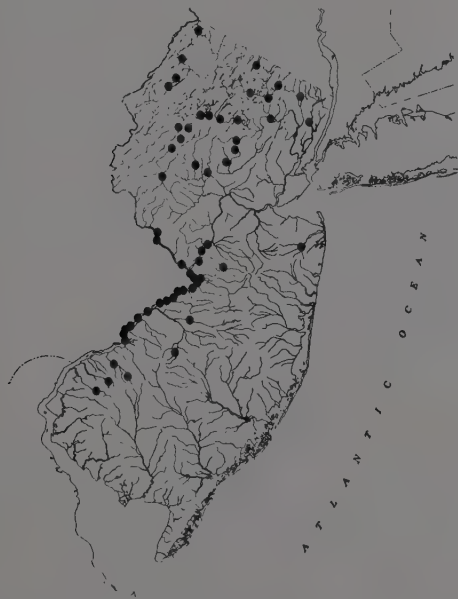
FIGURE 4.   Stream map of New Jersey showing locations of collections of *Orconectes limosus*.

Gloucester County

Alycon Dam, Pitman, Oct. 1, 1909.   H. W. Fowler and H. L. Mather.   ANSP 5173.
Mantua Creek, Mantua, April 8, 1906.   H. W. Fowler and S. H. Hamilton.   ANSP 1667.
Racoon Creek at Route 45, Mullica Hill, Sept. 15, 1957.   DDF 61.
Oldmans Creek at Route 45, Harrisonville, Sept. 15, 1957.   DDF 62.

Hunterdon County

Alexsocken Creek above Lambertsville, July 27, 1914.   H. W. Fowler and H. H. Burton.   ANSP 5313.
Lamington River at County Road 523, Lamington, Aug. 22, 1957.   DDF 52.
Branch of South Branch of Raritan River at Route 22, Clinton, Aug. 22, 1957.   DDF 53.

Mercer County

Crosswicks Creek, Trenton, May 21, 1905. H. W. Fowler. ANSP 5090.

Delaware River, Duck Island, Aug. 20, 1909. H. W. Fowler, C. C. Abbott, and T. D. Keim.
    ANSP 5018.

Assunpink Creek at Route 130, Windsor, March 18, 1957. DDF 18.

Baker Basin Creek, Lawrence, Aug. 23, 1957. DDF 55.

Stony Brook, Princeton, Sept. and May 30, 1898. Ortmann (1905a: 131).

Delaware-Raritan Canal at aqueduct, Princeton, Jan. 1899. Ortmann (1905a: 131).

Trenton. Abbott (1873: 80).

Trenton. Faxon (1885b: 86).

Assumgerich (?) Creek, July 24, 1884. MCZ 12640.

Monmouth County

Red Bank. Faxon (1885b: 86).

Morris County

Hurd Cove, Lake Hopatcong, Sept. 25, 1916. R. H. Abbott and H. W. Fowler. ANSP 5174.

Rockaway River, Denville, March 16, 1957. DDF 10.

South Branch Raritan River at Route 46, Budd Lake, March 16, 1957. DDF 11.

Musconetcong River at Route 46, Hackettstown, March 16, 1957. DDF 12.

Branch of Rockaway River from Lake Hopatcong at Route 15, Jefferson Twsp., March 16, 1957.
    DDF 16.

Dover, July 1884. C. C. Abbott. MCZ 3753.

Whippany River at Route 202, Morristown, August 22, 1957. DDF 47.

Primrose Brook at Route 202, Jockey Hollow, Morristown, Aug. 22, 1957. DDF 48.

Schooley's Mountain. Faxon (1885b: 86).

Schooley's Mountain. A. Mayor. MCZ 3452.

Passaic County

Greenwood Lake, Hewett, March 15, 1957. DDF 8.

Pequanock River at Dam on Route 23, West Milford, June 9, 1957. DDF 35.

Signac Brook at Route 46, Signac, Aug. 22, 1957. DDF 46.

Pompton Lake, July 20, 1936. J. A. Chuver (?). MCZ 9566.

Sussex County

Schwartzwood Lake, Oct. 5, 1895. S. N. Rhoads. ANSP 5612.

Schwartzwood Lake Outlet, Oct. 21, 1917. E. S. and M. L. Mattern. ANSP 5320.

Saw Mill Lake, Stokes State Forest, June 9, 1957. DDF 39.

Culvers Lake at Route 206, Branchville, June 9, 1957. DDF 41.

Sommerset County

Passaic River at Route 202, Bernardsville, Aug. 22, 1957. DDF 50.

North Branch Raritan River at Route 202, Far Hills, Aug. 22, 1957. DDF 51.

Warren County

Muscontecong River, Port Clinton, Aug. 8, 1916. H. W. Fowler and W. L. Mattern. ANSP
    5305.

EXPLANATION OF FIGURES

FIGURE 5. *Cambarus bartoni bartoni.* **1.** Carapace. Male, carapace length 30 mm.
Delaware Creek one-half mile from Delaware River, Delaware, Warren County, March 16,
1957. DDF 15. **2.** Right chela. Same specimen as number 1. **3.** Lateral aspect of right
form I gonopod. Same specimen as number 1. **4.** Seminal receptacle. Female, carapace
length 28 mm. Musconetcong River, Hackettstown, Morris County, March 16, 1957. DDF 13.
5. Lateral aspect of right form II gonopod. Male, carapace length 26 mm. Little Flat
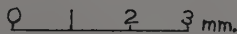Brook, Hainsville, Sussex County, June 9, 1957. DDF 40.
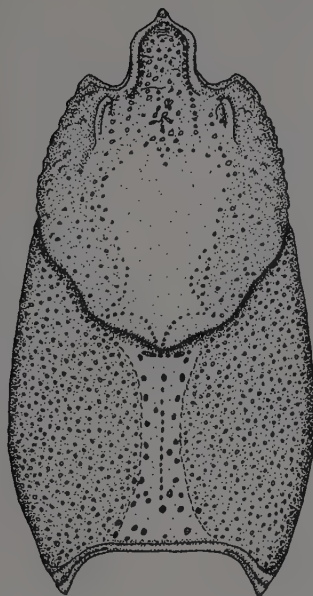
New Jersey localities not known

Hamilton, Mexico (?) County, June 1, 1884.   W. Faxon.   MCZ 3687.

Delaware River, Newbold Island, Aug. 13, 1908.   H. W. Fowler and T. D. Keim.   ANSP 5089.

Tienehill Hill west of Dundee Bridge, May 4, 1901.   E. Smith.   AMNH 4042 and 4040.

Mt. Abry.   Hagen (1870: 60).

Fornton, Nov. 26, 1872.   C. C. Abbott.   MCZ 3538.

Delaware River localities on Pennsylvania side

Philadelphia County

Holmsburg, July 4, 1898.   H. W. Fowler.   ANSP 1355.

Holmsburg, July 4, 1899.   H. W. Fowler.   ANSP 1453.

Holmsburg, Sept. 1904.   Ortmann (1905a: 131).

Torresdale Fish Hatchery, Oct. 26, 1911.   H. W. Fowler and J. R. Berkhouse.   ANSP 5166.

Near Philadelphia.   Rafinesque (1817: 42).

Torresdale Fish Hatchery, Sept. 1904.   Ortmann (1905a: 131).

Bucks County

Below Bristol, May 12, 1908.   H. W. Fowler and T. D. Keim.   ANSP 5300.

New Hope, Sept. 1904.   Ortmann (1905a: 131).

Penns Manor.   Ortmann (1906: 356).

Bristol.   Faxon (1885b: 87).

Cambarus bartoni bartoni (Fabricius)

Figures 5 and 6

Astacus bartoni Fabricius, 1798: 407.

Astacus ciliaris Rafinesque, 1817: 42.

Astacus pusillus Rafinesque, 1817: 42.

Astacus affinis Milne-Edwards, 1837: 332.

Cambarus bartoni Girard, 1852: 88.

Cambarus montanus Girard, 1852: 88.

Cambarus pusillus Girard, 1852: 88.

Cambarus (Bartonius) bartoni Ortmann, 1905a: 117.

Cambarus (Ortmannicus) bartoni Fowler, 1912: 340–341.

Type locality.—"Habitat in America Boreali."   Fabricius (1798: 407).

Taxonomic remarks. —New Jersey specimens of *C. b. bartoni* agree with the excellent descriptions given by Ortmann (1906: 377–380) and Fowler (1912: 344–347). There are many subspecies of *C. bartoni* and much intergradation and regional variation exist. Since the type specimen of this species probably was collected near Philadelphia the New Jersey, *C. b. bartoni* may be taxonomically closer to this than specimens from any other part of the country. Mr. Rendell Rhoades (personal communication) has commented that the *C. b. bartoni* from the midwest are as different from the typical eastern form as many described subspecies. The *bartoni* complex is indeed complicated and much more work is needed before it is completely understood.

Habits.— *Cambarus bartoni bartoni* is almost invariably found in small streams having cold, well oxygenated water, and on a bottom of stones, sand and gravel, or rubble. The author has not taken this species from a lake, but has examined a form I male from Schwartzwood Lake collected by S. N. Rhoads (ANSP 1308). *Cambarus bartoni bartoni* was collected from the Musconetcong River at Hackettstown along with *Orconectes* limosus. The Musconetcong is about 80 ft wide at this point. The specimen was collected near the bank in two ft of water. While the Musconetcong is a clean, well oxygenated river, it is large and does warm up considerably in the summer. This species may be considered, however, as a crayfish of the small, cold mountain streams. *Cambarus bartoni bartoni* also is found at considerable elevations as Lake Marcia near High Point.

The burrows of this species are made in the bank or in the stream bed under stones or rubble, where they may be quite elaborate. The burrows in the stream bed are detected easily in the

warmer months, when the crayfish are more active, by the fresh sand deposited at the entrance. Several times the author has removed one stone after another from the labyrinth of the burrow only to discover that the crayfish had left by another tunnel and was a few feet up stream.

Life history.—Seasonal data of the New Jersey *C. b. bartoni* agree with the life history information for this species given by Ortmann (1906: 487) and Crocker (1957: 65–68). Ortmann states, ". . . very likely *C. bartoni* has no defined spawning-season, but may spawn at any time of the year and that accordingly the mating-season is also not restricted to a particular time of the year." Ortmann further postulates that the uniform temperature of the streams where this species is found is responsible for the year around spawning season. Form I males have been found in every month of the year except January and February. This is undoubtedly due to the fact that very little collecting is done in January and February.

Distribution.—*Cambarus bartoni bartoni* is widely distributed from Tennessee to Maine and New Brunswick and westward to Indiana (Ortmann, 1905a: 122). Ortmann further states, "Eastward, it hardly descends to the Atlantic Plain, at any rate it does not spread over it. . . ." In New Jersey the species descends to the edge of the Atlantic coastal plain and inhabits the glaciated piedmont plateau area north of Trenton (fig. 6). This species had its origin in the Southern Appalachian system and migrated north along the mountains (Ortmann, 1906: 447).

FIGURE 6. Stream map of New Jersey showing locations of collections of *Cambarus bartoni bartoni.*

New Jersey Records of Cambarus bartoni bartoni

Bergen County

Saddle River at Route 4, Ridgewood, March 15, 1957. DDF 5.
Bear Swamp Brook, Darlington, March 15, 1957. DDF 6.

Essex County

Maplewood, July 1892. E. W. Smith. AMNH 252.
Orange. Faxon (1885b: 60).

Hunterdon County

Mulhocaway Creek at Route 22, Pattenburg, Aug. 22, 1957. DDF 54.
Stream flowing into Delaware River, Milford, May 29, 1935. H. Darby. USNM 74672.

Mercer County

Small streams near Princeton. Ortmann (1905a: 34).
Delaware River, Trenton. Abbott (1873: 80).
Trenton. Faxon (1885b: 60).

Morris County

Schooley's Mountain. Faxon (1885b: 60).
Schooley's Mountain, May 21, 1910. F. E. Lutz. AMNH 3988.
Musconetcong River at Route 46, Hackettstown, March 15, 1957. DDF 13.
Primrose Brook at Route 22, Jockey Hollow, Morristown, Aug. 22, 1957. DDF 49.
Schooley's Mountain. Hagen (1870: 75).

Passaic County

Pompton, May 1, 1910. F. W. Lutz. AMNH 4004.

Sussex County

Schwartzwood Lake, Oct. 5, 1895. S. N. Rhoads. ANSP 1308.
Branch of Franklin Lake at Route 23, Franklin, June 9, 1957. DDF 36.
Clove Brook at Route 23, Sussex, June 9, 1957. DDF 37.
Lake Marcia at High Point, Stokes State Forest, June 9, 1957. DDF 38.
Little Flat Brook at Route 206, Hainsville, June 9, 1957. DDF 40.

Union County

Plainfield, April 9, 1922. B. J. B. Hyde. AMNH 4025.
Green Brook, Scotch Plains, June 9, 1957. J. Krivacs and G. Bachofen. DDF 42.

Warren County

Beaver Brook at Pequest River, Belvidere Junction, March 16, 1957. DDF 14.
Delaware Creek, one half mile from Delaware River, Delaware, March 16, 1957. DDF 15.

Delaware River localities on Pennsylvania side

Bucks County

New Hope. Ortmann (1905a: 135).

Northhampton County

Easton. Ortmann (1906: 381).
Portland. Ortmann (1906: 385).

Philadelphia County

Holmsburg. Ortmann (1906: 384).

EXPLANATION OF FIGURES

FIGURE 7. *Cambarus diogenes.* **1.** Carapace. Male, carapace length 45 mm. Cohansey Creek, Bridgeton, Cumberland County, summer 1951. J. A. Starkey. USNM 92916. **2.** Right chela. Same specimen as number 1. **3.** Lateral aspect of right form I gonopod. Same specimen as number 1. **4.** Seminal receptacle. Female, carapace length 35 mm. Near Davis' Mill, seven miles west of Bridgeton, Cumberland County, May 25, 1958. J. A. Starkey. DDF 78. **5.** Lateral aspect of right form II gonopod. Male, carapace length 30 mm. Near Davis' Mill, seven miles west of Bridgeton, Cumberland County, May 25, 1958. J. A. Starkey. DDF 78.
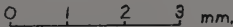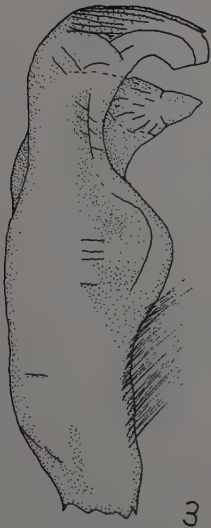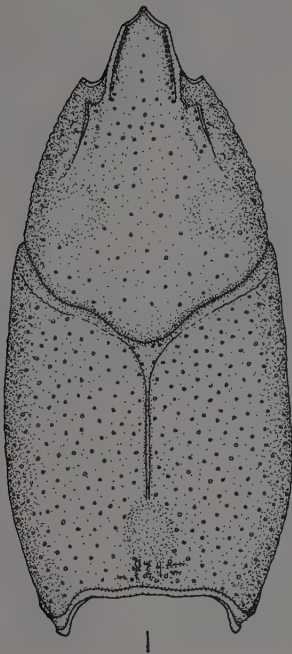
Cambarus diogenes Girard

Figures 7 and 8

Cambarus diogenes Girard, 1852: 88.
Cambarus obesus Hagen, 1870: 81.
Cambarus diogenenes Abbott, 1873: 83.
Cambarus diogenes ludovicianus Faxon, 1884: 144.
Cambarus dubius Osborn and Williamson, 1898: 144.
Cambarus (Bartonius) diogenes Ortmann, 1905a: 120.
Cambarus (Ortmannicus) diogenes Fowler, 1912: 340.

Type locality.—Washington, D. C.   Girard (1852: 88).

Taxonomic remarks.—Ortmann (1906: 407–409) recognized eastern and western forms of *C. diogenes.* Those found in New Jersey are of the eastern form. Only three New Jersey specimens of this species were examined by the author, a form I male (USNM 92916) collected by Mr. J. Albert Starkey at Bridgeton (fig. 7) and a form II male and a female with young (DDF 78) collected by Mr. J. Albert Starkey near Davis' Mill, seven miles west of Bridgeton. These specimens follow very closely the description of the eastern form of *C. diogenes* given by Ortmann.

The following differences were noted between these specimens and the typical western form. The areola is not completely obliterated as in the western form and the fingers of the chelae are considerably longer than the palm as contrasted to fingers approximately the same length as the palm in western specimens. There is a distinct notch at the base of the fingers in the eastern form caused by the arrangement of the tubercules on the movable finger. This notch is not apparent in the western form of this species. There is a lack of tuberculation on the dorsal surface of the palm in the New Jersey specimens, the tubercules being restricted to two rows on the inner edge. In the western form the tuberculation often extends half way across the dorsal surface of the palm. The most striking difference between the eastern and western forms is in the structure of the rostrum. Ortmann notes a tendency toward an acumen in the eastern form, but was not aware of its exact physical structure. Close examination of the New Jersey specimens shows that the swollen lateral margins of the rostrum terminate about four-fifths of the way along the rostrum while the supra-orbital ridges continue to the tip forming the acumen. In contrast, the western form has the lateral swollen margins of the rostrum continued to the tip while the supra-orbital ridges terminate about four-fifths of the way down the rostrum.

With insuficient material available for comparison and study, no positive statement can be made concerning the significance of these features. Should there characters be shown to be consistant in the eastern range of *C. diogenes* a subspecies certainly will be indicated.

Habits. —*Cambarus diogenes* is best known for the chimneys at the entrance of their burrows. These chimneys range from a few inches to as much as a foot in height and the burrows often extend three or more ft below the surface of the soil. The burrow is deep enough to collect water from the water table, run off or seepage and his obvious survival value for the species during the drier months. Many reasons have been offered to explain why these chimneys are constructed, but it seems sufficient to say that *C. diogenes* dig burrows and that the chimneys are a consequence of moving the excavated material out of the hole. The burrows themselves may be quite extensive, consisting of several branches and blind pockets.

Cambarus diogenes is nocturnal in habit. Its burrows, which are usually found in swampy areas or along streams but sometimes in quite firm ground, are made at night. The crayfish remain in the burrows during the day, but often leave them at night when feeding. This species is sometimes encountered a considerable distance from the nearest burrows and, in the spring of the year, even in open water.

Life history.—Ortmann (1906: 480) gives a good account of the life history of this species. The mating season is in August, September, October, and November and the spawning season in April, May, and the beginning of June. Except for a period of about one month in June and July, form I males are present the year round.

Distribution.—There are seven recorded localities for *C. diogenes* in New Jersey, five of which were supplied by Mr. J. Albert Starkey of Vineland. This species is found in the Atlantic

coastal plain south of Trenton and at Schooley's Mountain in Morris County, well within the glaciated area (fig. 8). *Cambarus diogenes* undoubtedly has a wider distribution in New Jersey than is now known.

Ortmann (1906: 459–462) places the origin of this species in southwestern Pennsylvania and northern West Virginia and postulates that it achieved its present range in the east either by descending from the mountains in a northeasterly direction or by being driven back from the north by the advancing ice, along with *Orconectes limosus*. This indicates that the Schooley's Mountain record is either an extension of the migration northward or a remnant of the retreat southward. Both of these theories suffer from a lack of information about the distribution of the species along the proposed migration routes. The author is of the opinion that the Schooley's Mountain record is a fingerlike extension of the northern migration and that *C. diogenes* descended from the mountains in a northeasterly direction to New Jersey. *Orconectes limosus*, which retreated from the north in front of the advancing ice (see distribution of *Orconectes limosus*), is common in southeastern New York and northern New Jersey. If *C. diogenes* had retreated from the north along with *O. limosus*, remnant populations of *C. diogenes* should be found in suitable localities in both New York and New Jersey. Since this species has not been encountered in New York (Crocker, 1957: 90), a northeasterly migration is indicated.

FIGURE 8.   Stream map of New Jersey showing locations of collections of *Cambarus diogenes*.

New Jersey Records of Cambarus diogenes

Cape May County

Opposite Bennett's Bog, Bennett.   J. A. Starkey.   Personal communication.

Cumberland County

Cohansey Creek, Bridgeton, Summer 1951.   J. A. Starkey.   USNM 92916.
Millville-Milmay Road.   J. A. Starkey.   Personal communication.
Gravel pit four miles east of Millville.   J. A. Starkey.   Personal communication.
Near Davis' Mill, seven miles west of Bridgeton, May 25, 1958.   J. A. Starkey.   DDF 78.

Mercer County

Delaware Meadows near Trenton.   Faxon (1885b: 71).
Trenton.   Abbott (1873: 83).
Trenton.   Fowler (1912: 352).

Morris County

Schooley's Mountain.   Fowler (1912: 352).

Delaware River localities from Pennsylvania side

Bucks County

Penns Manor.   Ortmann (1906: 405).

Delaware County

Ridley Park, Marcus Hook.   Ortmann (1906: 405).

Philadelphia County

Essington.   Ortmann (1906: 405).

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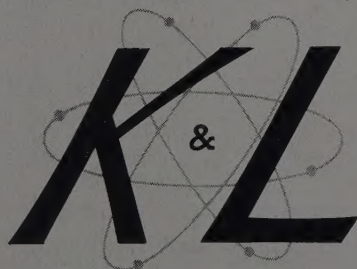
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